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Section of Odontology

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Forensic Aspects of the Teeth and Jaws

PRESIDENT'S ADDRESS

By Professor Evelyn Sprawson, M.C., D.Sc., L.R.C.P., M.R.C.S., L.D.S.

Several years ago, in conjunction with a colleague, I set a question in the dental surgery paper for a degree in dentistry which no candidate attempted to answer. I do not think it was a particularly difficult question, but it was novel, and asked what might be learnt of the age, habits and life-history of the individual from the study of the teeth and jaws. Really it is a very interesting study, and as no one has, so far as I know, tabulated what may be learnt from such a study, I am attempting here to answer the question, but on a wider aspect than that set in the examination paper. Some of the evidence which may be gathered in this manner is evidence of fact, some of probability and some perhaps of a rather hypothetical nature.

The various points which may be thought worthy of consideration can be grouped under different headings :—

Age.—The age of the individual may be assessed with relative but not absolute accuracy, chiefly from the teeth and to a lesser extent from the jaws.

From birth till the full eruption of the permanent dentition we have as guides the dates of the commencement of calcification, the eruption of the teeth, the absorption of the deciduous teeth and the amount of wear shown by functional teeth ; but the exactness of all assessments of age based on these evidences may at times be upset by variation within the range of normal. Thus, though it is usually taken that calcification of the mandibular permanent first molar begins at birth, American evidence on this point published some years ago showed that the calcification of this tooth, perhaps one of the most constant, had often not commenced at that time. Similarly I have seen this same tooth erupted at 4 years 10 months and unerupted at 7 years 6 months ; as in neither case was anything else abnormal found in these individuals one must allow for these variations as being within the range of normal.

Similarly isolated deciduous teeth, especially molars, may not be reliable evidence with regard to absorption, occasionally there are no permanent successors to these teeth, and though even in these circumstances their roots usually become absorbed such absorption is generally later, and occasionally it does not take place at all.

The rate of wear will also vary with the physical characters of the food and the functional activity of the teeth, and this latter will vary with the presence of dental caries, pain, the degree of occlusal perfection and the health and vigour of the individual. Deciduous teeth too show wear very much more readily than do permanent teeth.

The presence of diseases which may accelerate or delay the eruption of teeth must also be taken into account, remembering too that very rarely one or more deciduous teeth may be erupted at birth.

Concerning the jaws, the degree of growth, closing of sutures, measurement of the angle of the mandible, the condyle and the presence of sockets of teeth or their crypts are also evidence ; but in the total absence of teeth accuracy can only be relative, as the ages at

which the angle of the mandible increases and at which the loss of alveolar bone occurs depend to a large extent on whether and when the teeth were extracted or if they were lost from parodontal disease ; whether dentures had been worn, and whether these functioned efficiently.

Radiograms, especially when unerupted teeth are present, are a *sine qua non.*

Diseases of childhood.—On occasion, much may be learnt of the diseases of childhood from both deciduous and permanent teeth.

In the deciduous teeth the rare colour variations of the green teeth of icterus gravis neonatorum and the pink teeth of congenital hæmatoporphyrinuria are evidence, though the former must not be confused with the familiar green stain of teeth so often seen in uncared-for mouths, particularly of children, where the stain is superficial and its distribution different ; nor the latter with the teeth discoloured by extravasation of blood from the tooth pulps which may be seen in cases of death by strangulation, though this would no doubt be governed by the degree of patency of the dentinal tubules, itself governed by age and the degree of attrition shown by the teeth.

Hypoplasia of the deciduous teeth is usually only evidence of deficiencies in the maternal diet, and the evidence disappears with the deciduous teeth.

In the permanent teeth there is evidence which may persist throughout life. The transverse linear hypoplasia mostly seen on the incisor teeth is evidence of an acute short illness at the time the parts of the teeth affected were forming, but its absence, owing to the manner in which calcification takes place, is no evidence to the contrary.

The more common trophic form of hypoplasia (though nothing like so common as twenty years ago and earlier) is evidence of malnutrition, usually in the form of a dietary deficiency and often associated with rickets ; it affects most often incisors, canines and permanent first molars, in extent and degree according to the period the deficiency covered and its severity ; but it must not be confused with hereditary forms of hypoplasia where all teeth are equally and wholly affected, except that third molars are said to escape, nor with the local form which is evidence of local trauma or suppuration only.

The dental stigmata of congenital syphilis, affecting chiefly permanent incisors and first molars are pathognomonic to those who are familiar with them ; evidence that the deciduous teeth may be so affected is unsatisfactory, caries of the incisal edges of the anterior teeth, which is by no means rare, has apparently several times been recorded as being of specific origin, but it is usually believed that if the infecting agent is active at the time this part of these teeth is calcifying, abortion results. All congenital syphilitics, however, do not show the typical teeth.

The bones do not tell us so much. The saddle-shaped arch associated with rickets in conjunction with nasal obstruction is now almost a thing of the past. Necrosis of a greater or lesser portion of bone commencing during the acute stage of scarlet fever or measles may leave a permanent deformity and absence of teeth if tooth germs were in the alveolar portion of the sequestrum, but absence of teeth is so common from other causes that the evidence may not be of much value. Apart from these, clefts and the dental abnormalities associated with them, and the spacing of teeth due to unduly extensive fræna are almost the only other evidences of identity that the bones may give.

Manner of upbringing.—This affects the jaws, and indirectly the teeth of both dentitions. The efforts put forth by a child in the act of suckling tend to widen the jaws and so make room for the correct alignment of the teeth. This is perhaps emphasized about the age of 6 years, when the anterior teeth of the efficiently breast-fed child are well spaced and no longer in lateral contact, the jaws are also wider and the palate therefore appears flatter, and ultimately there is more room for the permanent teeth. I believe there are some who do not altogether agree with this, but personally I feel convinced of it, and should regard it as valuable evidence ; indeed, I look on the hand-feeding of children as providing a large proportion of the orthodontist's lifework.

"Mottled" teeth, usually caused by an excess of fluorine in the drinking water, give a hint as to localities in which childhood may have been spent, and its degree and extent may indicate the period spent there and even suggest the actual locality.

Heredity.—Heredity does not tell us much. The hereditary form of hypoplasia has already been mentioned ; it is not constant ; one parent is believed to be always affected ; it does not appear to be sex-linked, and, in any case, it is rare.

The congenital absence, or excess, of certain teeth it is known may be hereditary, but

the congenital absence of a tooth or teeth is difficult to surmise, as it may have been extracted, though X-ray evidence before its normal date of eruption may prove its absence. Similarly excess teeth may also have been extracted. Hereditary variations of the bones of the jaws also exist but are not common, and subsequent orthodontic treatment may have masked them.

Size.—Variations in the size of teeth do not tell us much, whether they be confined to one or two teeth only or general to the whole dentition ; with one exception all the cases of exceptionally large teeth that I have seen in British mouths, whether local or general to the whole dentition, have been in males. Generally-large permanent teeth are usually preceded by similar deciduous teeth.

There are, of course, racial differences with regard to the sizes of teeth which may be recorded by measuring the dental index ; this divides various peoples into microdont, mesodont and megadont races, and the measurements run almost parallel to those of the gnathic index which records the degree of prognathism present.

Habits and occupation.—In a few cases evidence of habits and occupation may be shown on the permanent teeth. The special form of attrition shown on the maxillary incisor teeth of boot-lasters is well known, so also is that form of abrasion shown by the clay pipe smoker ; I have several times been assured by patients showing a well-marked pipe notch that they have only smoked pipes having vulcanite stems, but I am not convinced that vulcanite alone can cause this notch. Obviously both these marks are also indications of sex, in this country at least.

Similarly the small jagged notches, really small pieces chipped out, occasionally seen on the maxillary incisor teeth of women, and caused by biting off ends of cotton instead of cutting them, are both an occupation and sex mark.

" Erosion " cavities tell us several things : that the patient takes some care of the teeth, that they scrub too hard or use too stiff a brush or too abrasive a dentifrice, that they use their toothbrush in the wrong manner ; and they may also, dependent on which teeth are abraded most, indicate whether the individual is right- or left-handed. Why some of these cavities should be saucer-shaped and others V-shaped I do not know, but perhaps it is an indication as to whether the brush or the dentifrice is mainly at fault.

The form of anterior open bite shown by the thumb or finger sucker is good evidence, especially in childhood.

The rampant caries of the baker or confectioner is also of value, though rampant caries is apt to occur in others as well ; indeed I once saw a professional chocolate taster who had cervical caries on every tooth in an otherwise almost complete dentition. Extensive cervical caries has also been noted in young employees at chemical factories who had to do with the manufacture of sulphuric and tartaric acids.

Other out-of-the-way habits have been recorded as leaving their distinctive marks. Tomes recorded the case of a patient in the habit of constantly sucking lemons, who had dissolved most of the enamel off the labial aspects of the teeth, but still kept them polished.

The smoker will have such salivary calculus as he may have on his teeth stained dark brown, notably lingual to the mandibular incisor teeth, and the drinker of strong tea will often have it, or his dentures, stained black ; these two items also to some extent indicating sex.

The gingival margins may also have their story to tell, the blue line of Grisolle caused by chronic lead poisoning being usually indicative of occupation, though it may be of habits, and occasionally neither ; the line is not present when there are no teeth and is dependent on some degree of gingival infection.

A bismuth deposit also occurs under similar dental conditions when this drug is used in antisyphilitic treatment ; the mark is usually browner than that caused by lead.

At the same time the fact that a deposit of finely divided carbon at the gingival margin may cause a somewhat similar appearance, as also may a deposit of subgingival calculus, must not be forgotten.

People who use soot as a dentifrice also show it in their gums, sometimes as a line following the gingival contour and sometimes as a deposit tattooed into the actual gum tissue by the toothbrush bristles and following no special contour, and this may remain permanently.

Tribal marks are made in some primitive races by the filing away of portions usually of the maxillary incisor teeth and occasionally the removal of one or more anterior teeth ; though in the Australian aboriginal the removal of one or two maxillary incisor teeth,

when practised, is not of this nature but apparently part of the initiatory ceremonies at puberty.

In other countries the stained teeth of the betel chewer may also be evidence of value.

The degree of attrition seen on the permanent teeth gives some indication of the habits, especially masticatory habits, of the individual, and in the case of the Esquimaux is some indication of sex ; it is the duty of the Esquimaux ladies to soften and render pliable the seal skins used for clothing and this they do by masticating them ; so, it is said, is their greater degree of attrition produced ; but the wide arches of the Esquimaux are in themselves indicative of race and prolonged suckling.

Dental diseases, abnormalities in the position of teeth, and conservative work.—The presence of dental caries, and its site, is vaguely informative, it generally preponderates in civilized races, and its conservative treatment should indicate a higher and more recent degree of civilization. Its absence in childhood or young adult life may indicate some degree of dietetic perfection rather than conservative care, and when caries is rampant and untreated at this age it certainly indicates the absence of both, particularly perhaps in the permanent maxillary incisor teeth.

The presence of a chronic anterior gingivitis, especially in the young, is indicative of physical imperfection apart from the teeth and jaws, as it is almost pathognomonic of "mouth-breathing" occasioned by nasal obstruction dating from childhood, and the habit and its results may remain permanently even after nasal patency has been established, unless steps are taken to restore proper nasal function.

A general gingivitis and its so frequent sequel of parodontal disease may guide one in assessing the degree of dietary perfection during the growing period with regard to both the chemical and physical attributes of the foods taken, and may also indicate the degree of care taken of the teeth by the individual, and so be some guide to social status.

The crowding of teeth depends on a great variety of causes, some of which have already been touched on, and their persistence to produce such result may indicate many things, among them being degree of civilization, dietary imperfection, care taken and, occasionally, heredity ; and the sometimes obvious fact that treatment has been undertaken gives some indication of social status.

The character and type of conservative work, if present, will indicate many things, including at present, social status and even perhaps nationality. The dentistry of necessity and the dentistry of luxury are of different types, though one must confess profound professional shame at that travesty of the dentistry of necessity at present provided for civilian war casualties. It does not do justice to the dental surgery of 1940. One hopes its continuance will be so short that its results may be of no forensic value.

Even more than conservative work the character and type of prosthetic restoration work, the materials used and the care taken of them are also indicative of social status, and perhaps of nationality.

Old fractures, whether of alveolar bone only or of the mandible, will all leave their immutable scars, and the same applies to losses of tissue from teeth, whether from trauma, attrition or caries, so long as teeth are present.

Speaking broadly, the teeth and parts adjacent to them, or even either by themselves, are as individual to their possessor as his fingerprints, but the former may, of course, be transient and not persist throughout life, but if the teeth are present in any numbers they may tell one many things about the life-history of the individual which one cannot learn from fingerprints.

That there are cases where the identity of an individual has been established from evidence akin to the foregoing is true in Australia, the United States and, I believe, in this country, but at present the subject is in its infancy.

I do not put the foregoing to you as being in any way exhaustive ; indeed I am only too well aware that I am merely indicating the fringe of the subject, and purposely omitting indications of several rare conditions, knowing full well that much could be added to the detail of what I have said, but such detail would carry us far beyond the confines of such time as may be taken up by a Presidential Address, even though it be on a subject on which so far as I know, nothing has been published in this country.

Section of Otology

President—LIONEL COLLEDGE, F.R.C.S.

[*November* 1, 1940]

DISCUSSION ON INJURIES OF THE EAR]

Mr. Lionel Colledge: There was an excellent discussion on injuries of the ear in the Section of Otology in 1911, to which Milligan and Cheatle made interesting contributions. The paper which Ballance read on that occasion forms the basis of the chapter on "Injuries" in the "Surgery of the Temporal Bone". He acknowledges his indebtedness to a book recently published by Passow. This work, published in 1904 and dedicated to the memory of Trautmann, contains a vast bibliography. Another book in German is "Surgery of Fractures of the Base of the Skull", by Voss, published in 1936. An excellent one, in French, on "Injuries of the Ear", by Ramadier and Caussé, was published in 1937. During the last war, which provided a large quantity of clinical material, Bourgeois and Sourdille produced a useful book entitled "Otites et Surdités de Guerre".

War injuries were discussed in this Section in 1917, when Marriage gave a good review of the subject, and again in 1920 when the principal contribution came from Jefferson Faulder. There was also a discussion on injuries of the ear arising from fractures of the skull opened by E. D. D. Davis in 1931, and in 1936 Kelemen demonstrated some histological preparations of temporal bones showing injury to the ear.

Injuries caused by explosions can be grouped roughly in two classes; those in which there is a gross tympanic injury which can be seen with a speculum even if it does not cause blood to escape from the meatus, and concussion of the labyrinth without signs of injury to the tympanum. The two may be combined, but most writers take the view, which is in accord with my own experience, that rupture of the tympanic membrane seems to exert some protective influence upon the labyrinth beyond. The actual effects upon the tympanic membrane from small interstitial hæmorrhages or small tears to almost total destruction are well known, but it is not so commonly recognized that the membrane may be blown out, the edges of the perforation being everted instead of inverted into the tympanum. Jefferson Faulder called attention to this, and associated with it the observation that the windows in one storey of a building may be blown into the room, whilst in another storey the glass may fall out into the street. In a recent experimental study of blast injuries to the lungs by Zuckerman it has been noted that the detonation of high explosives produces a wave of compression and then of suction. There is first a wave of high pressure followed by a wave of negative pressure, because the wave of compression reduces the density of the air behind it. The two together constitute the blast, the pressure component being more powerful and shorter, whilst the suction component is weaker and of longer duration. Faulder thought that the different effects might be produced according to the situation of zones of positive or negative pressure, but an alternative explanation is that an organ such as the tympanic membrane might withstand the force of compression and then be ruptured by the suction acting suddenly in the opposite direction and for a longer period. In the case of the tympanic membrane it might also happen that the rupture is caused by the compression and the eversion by the following suction.

There is a practical point to which my attention was frequently drawn during the last

war. Particularly in such units as Labour Battalions there were many men who had some form of chronic otitis, and often these were seen with hæmorrhage from the ears due to explosions which had caused bleeding from granulations or from the surface of the tympanum exposed through an old perforation. The significance of this in connexion with subsequent disability is evident, so that an accurate immediate diagnosis is important. I have seen such a case in a young woman recently in London.

Concussion of the labyrinth without necessarily a rupture of the tympanic membrane can be produced either by transmission of the effects of a blow on the head through the bones of the skull or by sudden increase in atmospheric pressure from an explosion. The latter is common in war, much less common in civil practice; but an explosion of firedamp would be an example of such a cause. Much has been written on this, but it is mostly speculative; there are, however, some experimental observations, and a few on material obtained from autopsies by J. S. Fraser and John Fraser.

Stenger subjected rats to blows on the head with various degrees of violence. In those animals in which there was no fracture the labyrinths were examined. Hæmorrhage was found into the cochlea, principally in the neighbourhood of the round window, but also in the ampullæ and between the fibres of the acoustic nerve. In the milder cases the hæmorrhage was limited to the neighbourhood of the round window and the first turn of the cochlea. The rest of the labyrinth was intact.

Prenant and Castex in 1916 submitted rabbits and guinea-pigs to the fire of artillery at Fontainebleau. They found the organ of Corti disorganized principally in the first and second turns of the cochlea, in some cases also hæmorrhages and other changes such as atrophy and shrinking of the nervous elements (described in detail), but in every case the static portion of the labyrinth remained intact.

Lastly, Ramadier quotes an interesting experiment by Hoesli, but I have been unable to trace the original paper. In these experiments it was shown that in animals deprived of the incus no labyrinthine lesion was produced by a revolver shot, whilst in animals retaining the incus a similar explosive force produced lesions at the junction between the first and second turns of the cochlea.

In confirmation of these experimental observations J. S. Fraser examined four temporal bones which were obtained in France by John Fraser from soldiers who died after exposure to severe concussion. The tympanic membranes were ruptured and there was hæmorrhage into the middle ear, with slight hæmorrhages into the scala tympani in the region of the round window and basal coil of the cochlea; also hæmorrhage at the fundus of the internal auditory meatus. The nervous elements of the cochlea showed degenerative changes and the organ had a ghost-like appearance.

Dr. Blegvad showed at a meeting of this Section in 1936 that in many cases the deafness caused by loud noises or continued noise is functional. I can here only just mention the well-known experiments of Wittmaack, Siebenmann and von Eicken on the subject of noise loud and prolonged. On the clinical side the observations of Ritchie Rodger are familiar.

Direct wounds of the temporal bone in warfare must be fairly common, but not many are seen and still fewer are recorded, probably because they are often immediately fatal. Most of the wounds caused by firearms have been studied in cases of suicide. In these naturally the projectile is a small bullet fired from a pistol without much power of penetration. Such cases have been frequently recorded but they are not of great interest.

Portmann made a study in the clinic of Prof. Moure at Bordeaux after the last war based on 42 cases of gunshot wounds of the ear. In 14 cases the projectile was in the tympanum, in 21 in the mastoid, and in 7 in the petrous. He mentions that for the extraction of such foreign bodies a supra-auricular route was suggested by Paul Berger as long ago as 1888, and a pre-auricular route was suggested by Gangolphe in 1894. The latter method would give very poor access even if the parotid were retracted forwards, and it was suggested that the temporo-mandibular joint should be dislocated to provide more space. This would be most destructive, and the method of approach has nothing to recommend it. If the foreign body cannot be extracted through the meatus the proper route is by a retro-auricular incision. In most cases the damage to bone is so extensive that the radical operation is necessary, and this should certainly be done if the labyrinth is injured or the projectile is impacted in the petrous.

Le Mée has suggested that the exposure may be further increased by extending forward each extremity of the usual incision. The membranous meatus can then be

dissected off its attachments, the parotid retracted, and the pre-auricular region thus exposed.

Apart from intracranial infections, the most common sequelæ of such wounds are facial paralysis and ankylosis of the temporo-mandibular joint.

Quite a different form of injury is associated with aviation. Aviators are naturally subjected to rapid changes in atmospheric pressure during ascent and descent, though injury to the ears has long been known both in caisson workers and aeronauts. The action of these changes of pressure on the tympanum is normally compensated by ventilation through the Eustachian tube whereby the pressure in the middle ear is equalized with the atmospheric pressure. The physiology of the Eustachian tube under these conditions has been studied experimentally by Armstrong and Heim. The investigations were made on five healthy men subjected to changing rates of pressure varying from 5·4 to 27 mm. of mercury per minute, corresponding to 200 to 1,000 ft. of altitude per minute, through ranges of pressure from 141 to 760 mm. of mercury, corresponding to 0 to 40,000 ft. in altitude. By decreasing the pressure from sea level at a constant rate it was found that a change of 3 to 5 mm. of mercury, or 110 to 180 ft. in altitude, was required to produce any effect. The discomfort increased until at 15 mm. of mercury, or 500 ft. in altitude, an involuntary click was felt in the ear and the sensation of fullness was relieved. Succeeding clicks occurred at intervals of 11·45 mm. of mercury, or 435 ft. in altitude, the succeeding clicks during ascent corresponding rather to the changes in altitude than to identical increases in rarefaction. When the atmospheric pressure was increased, as it would be in a sudden descent, a totally different effect was obtained. The Eustachian tube remained closed under all degrees of pressure, and finally the tympanic membrane ruptured unless the tube was opened by a voluntary act of swallowing, which becomes impossible when a negative pressure of 80-90 mm. of mercury is produced in the middle ear. In actual aviation the capacity to compensate for these changes by opening the Eustachian tube is important, and any tubal catarrh or stenosis which prevents this may cause acute congestion of the tympanum or even rupture of the membrane with symptoms varying from deafness with vertigo and tinnitus to sudden acute pain with the sensation of a blow followed by nausea and collapse in the case of rupture. If a negative pressure in the middle ear beyond 80-90 mm. of mercury is produced, however, the Eustachian tube cannot be opened voluntarily, and relief, short of rupture of the membrane, can only be obtained by returning to a higher altitude. The damage to the ear in these circumstances is described as acute aero-otitis media. The discomfort and deafness with retraction and stretching of the membrane caused by repeated experiences of this kind is called chronic aero-otitis media.

Apart from effects of this kind upon the middle ear, workers in compressed air may develop labyrinthine symptoms amongst the manifestations of caisson disease soon after decompression. There is a sudden onset of vertigo, tinnitus and deafness. Recovery may be complete, but according to Bertoin there may be permanent loss of function, both cochlear and vestibular.

Although fractures of the skull involving the temporal bone are sometimes limited to the external and bony meatus, to the mastoid process, or even to the walls of the tympanum, the most important are those which pass through the petrous portion. Statistics showing the proportion of cases in which the petrous portion of the temporal bone is concerned in fractures of the skull vary and are probably misleading, but it is fairly high, perhaps in the neighbourhood of one-quarter or even more. The cause is usually a blow or a fall on the head, less commonly the violence may reach the skull indirectly from a fall in the sitting position or on the chin. The fracture of the petrous, however, is always indirect, and reaches it by radiation, though rarely the petrous alone is fractured. It is now considered, however, that these independent fractures of the petrous are more common than was formerly believed. Usually the fracture radiates from some part of the vault into the anterior, middle, or posterior fossa. The line may not extend beyond one fossa or it may cross the buttress of the great wing of the sphenoid or the petrous into a neighbouring fossa. Although the petrous appears to form a solid buttress, it is less strong than it seems because it contains the cavities in which the organ of hearing is lodged. The petrous may thus be reached by a fracture from the temporo-parietal region crossing the middle fossa and producing a longitudinal, rarely a transverse, fracture, or, secondly, it may be reached from the occipital region across the posterior fossa so that a transverse fracture is produced or the tip of the

petrous broken off, or the fracture may be oblique. Of these three varieties of fracture of the petrous—longitudinal, transverse, and oblique—the longitudinal is the most common, exceeding in frequency the transverse and oblique combined. It is impossible, however, to fit every fracture into such a rigid classification, for the line or lines of the fracture do not in every case follow the typical route and the classification is only schematic, though most cases conform to it. There is also another fracture of great importance in the present connexion, namely, fracture of the bony labyrinth which can only be demonstrated by the microscope.

In the longitudinal fracture of the petrous the line runs down from the squamous portion of the temporal bone or from the parietal bone just behind. In the first case it crosses the external auditory meatus and the tegmen tympani. In the second case the line first crosses the upper part of the mastoid process and then reaches the tegmen. From the tegmen the line follows the anterior aspect of the petrous pyramid to the depression for the gasserian ganglion along the upper wall of the Eustachian tube and the carotid canal.

The petrous is thus divided into two unequal parts : an anterior which includes parts of the external auditory meatus and of the middle ear, and a larger posterior portion which includes the aqueduct of Fallopius, the internal auditory meatus, the whole of the internal ear and part of the middle ear. Thus the middle ear is always involved in the fracture and the tympanic membrane is torn in almost every case. On the other hand, the internal ear remains intact and the facial nerve usually escapes.

In the transverse fracture which follows a blow on the occiput or the mastoid region, the line passes forwards across the petrous somewhere in its middle third at right angles to the long axis, starting from the jugular foramen. This track may pass across the internal auditory meatus, to the foramen spinosum, or may lie more externally and pass right across the labyrinth and the aqueduct of Fallopius. In the latter case the internal wall of the middle ear is fractured, but in neither case is the tympanic membrane torn. On the other hand, the facial nerve is likely to be injured either at the internal auditory meatus or in the aqueduct.

Thus in the typical longitudinal fracture the membrana tympani is torn and the middle ear opened, whilst in the transverse fracture the tympanic membrane remains intact, but the facial nerve is liable to injury and the labyrinth is fractured.

The oblique type of fracture is caused by a blow on the occiput. It starts from the most postero-external part of the petrous or the posterior surface of the mastoid process in the neighbourhood of the lateral sinus and passes forwards and inwards. The line of fracture thus includes the mastoid process, the posterior wall of the meatus, the tegmen tympani, and the middle ear, the internal ear and the aqueduct. The tympanic membrane is torn and this type of fracture combines therefore the principal characters of both the longitudinal and the transverse fracture.

In exceptional cases which do not fall within these three categories atypical fractures have been described, such as one mentioned by Cheatle in which the line of fracture taking a curved course cut off the middle ear, the external auditory meatus, and the outer wall of the antrum from the rest of the petrous.

Mr. Jefferson called my attention to a remarkable case of double transverse fracture of the petrous described in 1867 by Jonathan Hutchinson. In this case a man received a blow on the right parietal bone from a fall into the hold of a ship. He made a partial recovery but became quite deaf and then died from erysipelas and pyæmia. At the autopsy there was a double transverse fracture of the petrous, the line starting on each side from the edge of the foramen magnum and meeting in front of the body of the sphenoid. Neither tympanic membrane was ruptured but the middle ear contained blood.

Of great interest is the microscopical fracture of the labyrinth, the existence of which has long been suspected and has now been proved by pathological study of temporal bones. These fractures, which are not visible to the naked eye, may be seen by radiological examination, but their existence can only be proved satisfactorily by the microscope. The fracture may be of the transverse type or entirely confined to the labyrinthine capsule. The site of election for such fractures of the capsule is at its weakest part in the region of the oval and round windows ; the thin ridge of bone between them is fractured, possibly also the footplate of the stapes, and the membrane closing the round window is torn. The footplate of the stapes may be broken into fragments which override one another or become comparatively widely separated. The line

of the fracture may spread inwards across the cochlea to the internal auditory meatus. On the other hand, the fracture may consist, as Nager has shown, of a number of fine complex tracks which break up the capsule of the labyrinth like a crushed eggshell. The old observation attributed to Malgaigne, that fractures of the skull unite slowly and by fibrous union only, has been proved to apply to these fractures of the labyrinth. This defective repair carries with it special and remote dangers in the region of the middle ear, because the fibrous scar, which is weak or may scarcely exist at all, forms an ineffective barrier to the spread of an infective process. This relationship between labyrinthine injury and late meningitis has been studied particularly by Nager.

In the cortex of the petrous the fracture unites by solid bone, but in that part of the labyrinth which forms in the inner wall of the middle ear—that is, the promontory and the region of the oval and round window—there is fibrous union only; there may even be gaps in this and the fragments of the stapedial footplate may remain separated without any attempt at repair. Nager has been able to demonstrate by histological sections of the temporal bone from a patient, who died from meningitis six months after a head injury, the passage of inflammatory granulation tissue and leucocytes from the middle ear to the cochlea through a defect in the promontory. Nager has also shown that the labyrinthine capsule consists of three layers. An endosteal layer of embryonic bone forms a thin lining to the cavities. A periosteal layer of diploetic bone capable of repair by bony union is relatively thick in the neighbourhood of the dura mater but deficient in the region of the promontory and the two windows. Between these is an enchondral middle layer. This enchondral layer does not undergo the process of growth and ossification which proceeds normally in other parts of the skeleton. In the labyrinth it remains permanently in an embryonic stage, immune from the ordinary processes of absorption and regeneration and equally immune from senile osteoporosis, but also lacking the capacity of repair. As this layer forms almost the whole thickness of the bone composing the promontory and the area around the windows, an explanation is afforded of the curious phenomena exhibited by the fractures under consideration.

It appears from this that a longitudinal fracture which lays open the tympanum and exposes it to infection carries with it some immediate risk of meningitis. On the other hand, transverse fractures or any other unclassified form of fracture which involve the labyrinth, without necessarily being accompanied by a rupture of the membrane, induce a permanent liability to meningitis from a chance attack of otitis media, which finds no resistance offered to an immediate invasion of the labyrinth. Thus Schlittler has recorded a case in which, after a head injury, the caloric reaction disappeared entirely on one side, but some power of hearing remained. Sixteen years later a very slight attack of otitis media was followed by meningitis, which proved fatal, and histological examination revealed a fracture of the labyrinth which was responsible for the meningitis.

Ramadier has collected the following records, some of which had already been noted by Nager, of this kind of late meningitis : 4 weeks (Scheibe), 4 weeks (O. Voss), 6 weeks (Politzer), 7 weeks (Klestadt), 6 months (Nager), 7 months (Rynter), 15 months (Ramadier), 15 years (Brocq), 16 years (Schlittler). The necessity for a guarded prognosis in such cases and the possible medico-legal implications are apparent.

Examination of the ear in head injury should follow the usual lines, but all syringing or lavage to clean the external auditory canal of blood-clot or other debris must be avoided. The membrane may, according to the nature of the deeper injury, be normal in appearance, may be torn and bleeding or less frequently may be intact but swollen and deep purple from an effusion of blood into the middle ear. In this case the blood may escape by the Eustachian tube into the nose or the pharynx. The escape of cerebrospinal fluid from the ear is a well-known sequel. It indicates a rupture of the meninges and the tegmen and clearly indicates the possibility of meningeal infection, but it is not necessarily fatal. It is also not necessarily associated with rupture of the tympanic membrane, as the fluid may escape by a fissure in the tegmen or it may fill the spaces of the middle ear without escaping by the meatus. Voss has described six cases of this peculiar phenomenon under the title of "Liquor tympanum". In this case examination of the ear shows the membrane bulging without discoloration and sometimes exhibiting a fluid level.

Davis has noted that the escaping ceresbrospinal fluid sometimes causes irritation of the skin. Tilley has explained this effect as due to the sugar in the fluid, and compared it to the irritation which diabetic urine causes to a sensitive skin.

The usual functional examination of the ear should also be made as far as possible, but too much emphasis is sometimes laid upon this as the general condition of the patient often prevents the examiner from making sufficiently accurate observations to be of any clinical value.

As a rule the treatment follows the general lines of treatment in head injuries and operation on the ear is seldom indicated. For the last thirty years, however, Voss has persistently advocated systematic operation when there is evidence of fracture of the petrous. He has long held that in such circumstances the radical mastoid operation should be performed, all clot, splinters and rough edges of bone removed, the track of the fracture followed and if necessary the labyrinth opened. He has no doubt carried this opinion further than is justifiable, on the analogy of the operative treatment required for fractures of the cranial vault, and has had but little following or support. On the basis of the pathological observations mentioned above, this method of treatment does, however, require serious consideration in special cases, especially since the control of infections by chemotherapy has so much improved the prognosis of meningitis.

The opinion which Nager has expressed, that in a case of old head injury with signs of fractured petrous, shown by deafness, absence of vestibular excitability and intact tympanic membrane, the earliest suspicion of meningitis calls for the radical mastoid operation and exposure of the labyrinth, is a good guide in a situation the dangers of which are not generally appreciated.

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Miss Josephine Collier: I shall deal only with those injuries of the ear produced among the civilian population by air-raid bombardments, basing my remarks mainly on experience gained in Barcelona during the Spanish War. My personal experience there was restricted to two visits, but I have had the advantage of obtaining information from Dr. Rafael Trueta, an ear and throat surgeon, who was consultant to the Hospital Clinico and the Red Cross Hospital there.

Dr. Rafael Trueta's own records deal with 600 patients with ear, nose and throat injuries treated at these hospitals, more than half of whom had injuries of the ear, and though I realize that with the intense bombardments of London now occurring many of us here will have the occasion to treat a much larger number of these casualties,

up to now there has not been an opportunity to analyse the types of injury and their relation to the various kinds of bomb used in aerial warfare.

I hope, therefore, that what I have to say may be of some value before our own experience has been able to crystallize out into practical judgment.

I do not propose to discuss injuries of the pinna, of which there are a large number among patients injured about the head and face, except to say that they are often associated with severe injuries of neighbouring parts such as the temporo-mandibular joint or the mastoid process, and though usually slight may involve partial or total loss of the pinna. Those wounds caused by bomb fragments or splintered glass heal better than those produced by falling masonry because there is less bruising of the tissues in the first group.

Injuries of the external meatus are generally due to penetrating wounds with the point of entry from the mastoid region or the face. Usually they are slight but very painful and may often be overlooked because of the other lesions present. Sometimes a small fragment of shell after traversing the cortex of the mastoid process and the posterior wall of the meatus becomes embedded in the external canal and requires careful removal.

Injuries of the middle ear should be divided into two groups. Those produced directly by the penetration of bomb fragments and those due to blast. In the first group the wounds have their entry by the mastoid process or the temporo-mandibular joint with fracture of the bony external meatus, and in the majority of cases fragments remain embedded in the mastoid or the middle ear. Patients with wounds of this region caused by large pieces of bomb seldom reach the hospital alive so that the clinical picture given here refers especially to injuries from light bombs with great power of lateral expansion. In these patients with mastoid wounds there is generally a fracture of the petrous temporal with bleeding from the ear, often with epistaxis and the other symptoms of a fracture of the base of the skull. The middle ear is always involved and sometimes the inner ear. Signs of associated cerebral injury with unconsciousness for several hours or days may be present, and it may be only when this stage has passed that symptoms of the middle ear lesion are noted, viz. tinnitus, deafness of middle-ear type and occasionally nystagmus. Those cases treated by an otologist in the first instance are likely to escape infection. A foreign body requires removal only when it is provoking severe reaction, e.g. pain and persistent discharge. This should be done by the radical mastoid operation as conservatively as possible because of the liability to intra-cranial infection. The prognosis with regard to hearing in these cases due to direct injury is always grave.

The second group, i.e. those produced by blast, includes the majority of ear injuries treated. Dr. Rafael Trueta found that in 208 consecutive patients with middle-ear damage 175 were produced in this way while only 33 resulted from the direct violence of bomb fragments.

The blast effect on the middle ear varies according to the explosive capacity of the bomb and the distance of the victim from the explosion. With medium case bombs, between 100 and 300 lb., rupture of the tympanic membrane with bleeding from the middle ear is liable to occur in those individuals within a radius of 50 feet who survive the explosion. Outside this radius hæmorrhage in the membrane followed by myringitis is produced, while between 80 and 120 feet there is emptying of the air in the middle ear such as occurs in other situations as a result of sudden changes of atmospheric pressure. Partitions and walls of buildings protect the individual against blast effects. Thus it was found in Barcelona that only 0·5 per cent. of those injured within buildings, excluding those actually within the room where the bomb exploded, suffered injury to the middle ear as compared with 40 per cent. of those injured in the street by the medium case 100 to 300 lb. bombs.

Dr. Trueta's statistics show that in addition to the middle-ear effects blast injuries produced labyrinthine irritation of short duration in 2 per cent. of cases.

Rupture of the tympanic membrane in these patients is accompanied by sharp pain, bleeding from the ear, and high-pitched tinnitus which soon changes to a low note. The deafness of middle-ear type—not severe—is overshadowed by the tinnitus and tends to recover fairly rapidly. The tinnitus is always the last symptom to disappear. If the otologist is able to treat these injuries from their onset the course is almost always

favourable and infection does not occur. Unfortunately in the majority of cases the tympanic lesion must take second place to more serious injuries of greater importance to life which demand immediate attention. Lesions of the middle ear are often discovered only when the patient recovers from the graver lesion, and by this time suppuration may have been established. Sometimes when examined because of deafness and tinnitus reported several days after the injury, a clot of blood is found in the middle ear the presence of which seems to be responsible for the continuance of the discharge which rapidly clears up on removal of the clot. Occasionally the tympanic membrane is found intact with signs of blood-clot within the middle ear.

When there has been no suppuration the deafness generally disappears in a few days but the tinnitus is more resistant. Occasionally it diminishes in about two weeks, i.e. when the tympanic wound is healed but in most cases it remains severe for many months.

Treatment of these ear lesions is simple. If the patient is seen during the short period while bleeding from the ear is in progress it is best to assist drainage by laying the patient on the affected side. If a clot has already formed in the tympanic wound aspiration with a Siegle speculum is necessary, followed by closure of the external meatus by sterile gauze. If suppuration is already established when the patient seeks advice the treatment follows the usual lines and recovery is generally rapid. In over 200 patients Dr. Rafael Trueta had only two cases of chronic suppuration.

The persistent tinnitus is less easily relieved. That there may be a psychological factor in addition to the ear damage is suggested by the fact that a short holiday away from the noise and dangers of the bombarded town generally gave good results.

As one would suspect, the presence of nasal obstruction contributed to the incidence of tympanic lesions, 65 per cent. of patients having this abnormality. In Barcelona they also found that tympanic injuries were more frequent in men than in women, probably because the latter are more likely to cry out at the approach of the bomb thus maintaining the balance of atmospheric pressure on both sides of the tympanic membrane. The practice of placing a pipe or pencil between the teeth when the fall of bombs seemed imminent was found to diminish the incidence of tympanic injuries and was widely employed both in the towns and at the front. The ear protector that gave the best results in preventing tympanic injury consisted of a small plug with a valve that remained open save when the external pressure was increased, rather on the lines of the Mallock Armstrong defender. It is perhaps unfortunate that the rubber plugs now being distributed to the civil population as part of our A.R.P. services have not been designed on similar lines.

The types of bomb now being used against this country do not differ in any fundamental feature from those employed in Spain. The so-called "land-mine" produces its effects by the widespread propagation of blast. We would expect, therefore, to find a large number of patients with lesions of the type I have described. I believe, however, that walls and partitions protect the individual against this and only those in the street within the radius of the explosive force are liable to traumatic rupture of the tympanic membrane. Actually I have seen very few patients with these injuries from land-mines. I shall be interested to hear the experience of other members of the Section.

Conclusion.

Serious injuries to the ear from the direct violence of bomb fragments are seldom seen as air raid casualties because such head injuries are commonly fatal. Traumatic rupture of the tympanic membrane is, however, a frequent result of exposure to blast. The Barcelona figures show that between 30 per cent. and 60 per cent. of those injured by high explosive bombs have middle-ear injuries depending on the distance from the explosion and the explosive capacity of the bomb. These lesions are frequently overlooked in the first instance and are consequently neglected until suppuration has occurred. The percentage figures given above were observed in Spain only when routine examination was instituted several months after air raids had become frequent. I think, therefore, it is the duty of otologists here to advise the casualty services that routine examination of the ears should be made as soon as the general condition of the patient permits in order to make an early diagnosis of tympanic injury, which may well be the means of preventing chronic suppuration and persistent deafness.

Mr. V. E. Negus said that he had had the opportunity of seeing a considerable number of injuries of the head and neck, and, with the assistance of his registrars and medical officers, of classifying the cases and comparing the civilian and the military injuries. He showed a table analysing 622 civilian air-raid casualties, with a total of 199 head injuries. Most of these had been in the wards which he looked after—some in other parts of the hospital—before transfer of the more serious cases for special treatment. A few might have been missed where there had been associated injuries of greater gravity which necessitated admission to some other ward. The cranio-cerebral cases—as distinct from other head injuries—number 129. Injuries of the face were relatively few—33—and those of the eye numbered 36. The total number of ear cases was 24, or 3·8% of the casualties.

The military casualties numbered 1,417. These were chiefly war casualties, with the addition of some accidents, as it was impossible to separate them. The cases of head injury numbered 165. The only deductions to be drawn from that relatively much lower figure were that the steel helmet protected the soldier; also that when head wounds were sustained they were probably more often fatal, whereas among civilians a considerable number were slighter injuries due to glass, bricks, and so on, and not fatal.

The military cranio-cerebral cases numbered 82, or 5·7% of the total injuries, and the ear cases numbered 29, which was only 2%. Thus there had not been a great many cases on which to make observations, and the chief value of the figures was the comparison with the total injuries.

Of the ear cases the majority had traumatic rupture of the tympanic membrane. Amongst the total of 24 ear cases in civilians, each of whom had only one injury, there were 16 cases of ruptured tympanic membrane, and among the 29 ear cases in the military, with a total of 33 injuries, the corresponding number was 22.

These figures gave some idea of the expectation of injuries among cases admitted to a general hospital. The cases amongst civilians, of course, were only those sent to hospital. There might be some who were well enough to go home, and of these he could not speak. Practically all the ear cases had been associated with other injuries. Of the very few in which there was no injury to the rest of the head or body, but only a rupture of the tympanic membrane, the cause in the majority had been blast, associated with its other effects, such as cerebral hæmorrhages, as one could discover by lumbar puncture.

Of the external ear injuries there was nothing very much to be said. In cases where there was a threatening perichondritis the application of 10% silver nitrate seemed to be a useful preventive of extension. It had certainly averted some of the cases.

Injuries of the external meatus were few. One difficulty was the treatment of atresia. Fragments of bone had to be removed, and if there were definite atresia threatening, causing difficulty in clearing up suppuration, the right treatment was, he thought, a mastoid operation of a modified type, removing the party wall between the mastoid antrum and the tympanic cavity, taking away the bridge and incus, and preserving the tympanic membrane. This left a more or less normally functioning tympanic cavity protected by a membrane.

He exhibited a diagram illustrating the appearances of the perforation in the various cases of ruptured tympanic membrane. Symptoms had been very slight. He had not heard patients complaining to any extent of tinnitus or vertigo. The patient had noticed very little, and it had required a routine examination of cases to discover some of these ruptures. Such examination should be insisted upon in all cases of head injuries because of the serious effects, from the patient's point of view, which might follow an infection of the ear.

The position of the rupture was of interest. He had seen it mentioned elsewhere that the rupture was more often in the posterior segment, but in the cases he had seen the rupture was much more often in the anterior and inferior segment. For various reasons it would appear that the perforation was due to the positive wave, and, as Mr. Colledge had pointed out, the eversion of the edges was probably due to the suction wave. His diagram gave some idea of the appearance of the perforation, which was clean cut and showed very little reaction. It was as if a ramrod or piston had pushed a hole through the tympanic membrane in the region of the Eustachian tube, where it was

unsupported on the other side. Two, only, showed effusion into the tympanic cavity without rupture. One or two showed dilatation of vessels in one ear and perforation in the other side.

In treatment the ear should be left alone. The meatus and the external ear should be purified. Personally he found biniodide of mercury in spirit a good antiseptic and one which left the ear dry. The presence of moisture predisposed to infection. Any cerumen, which might contain a large number of bacteria, was removed carefully. But the deeper parts of the meatus should be left strictly alone; there should be no instillation of drops or anything of that kind. These cases all got well. There had been no instances of acute otitis media and very few of suppuration. In the case of an officer who had been blown up by a land-mine, and whose ears were suppurating, on admission, with staphylococcal infection, the suppuration continued for 70 days, and then ceased. None of the cases had gone on to acute otitis and none to mastoiditis. They had all been given sulphapyridine for three days and had the ear purified and cotton-wool kept in. He deprecated the practice of pushing wicks of gauze or other material into the ear. Only one of the cases had been due to direct injury; the others were caused by the effect of blast.

Spread to the mastoid had not occurred, but if it did occur there was another principle which should receive general acceptance, and that was that any operation on the mastoid process should be delayed, certainly for two weeks, and not performed early—a course which might be followed by some who had not extensive experience and had not the assistance of specialist opinion. Of the wounds of the mastoid process, there had been only two cases. There might formerly have been a possibility of difference of opinion as to immediacy of operation, but he thought that now, after the introduction of chemotherapy, everything pointed to the wisdom of delayed operation. Fragments of loose bone or any obvious pieces of metal should be removed at the time, but no extensive operation should be performed. In the section on the ear in the "Medical History of the War" it was recommended that as these cases were extremely dangerous there should be an early and extensive clearance of the mastoid air cells. But he thought the position had been changed by the introduction of the sulphonamides; operation should be delayed, though it might be necessary later.

The escape of cerebrospinal fluid had occurred in one case; this was not of great account so long as there was no syringing, which would drive infection inwards. Therefore the ward-sisters had definite instructions that no ears were to be syringed without explicit directions from the medical officer.

Of internal ear wounds he had not seen any in the present war; this was a region which, if injured, was likely to cause death. Fractures of the base of the skull involving the inner ear had also been very uncommon.

As to the effects of blast in producing internal ear deafness, there could not be any doubt that there were hæmorrhages into the labyrinth. There had been a number of cases of patients who had been unconscious, with hemiplegia and so on, with obvious signs of a disruptive process in their central nervous system. Such patients, with blood in the cerebrospinal fluid, had all got well. They had no extra- or sub-dural hæmatoma. If blast could affect the cerebrospinal fluid system and the lungs in that way, one would think it was quite easy for hæmorrhages to occur in the internal ear, but they seemed to be rare.

Injury of the facial nerve in the cases he had seen had been extremely rare; it had happened about twice.

Mr. F. W. Watkyn-Thomas said that the points had been so thoroughly covered by Mr. Colledge and others that there was little to say. As to the effect of the alternating wave of pressure and suction, he thought this could be taken as proved. Walking through damaged areas it would be noticed that windows had either been blown out or blown in, in equal numbers. The same thing must apply to the tympanum. The petechiæ which were sometimes seen on the tympanic surface where there had been no rupture were a fairly good proof of suction. As to pressure, he recalled a case of a naval officer who, after a large bomb had been dropped close to his ship, was seized immediately with pain and deafness. He saw him a week later, and discovered that a large plug of wax had been firmly driven on to his tympanum; this had been done so completely that the wax had actually taken the impression of the malleus and the short process. When this was removed, pain ceased and hearing was restored.

As to the recrudescence of old suppurations after explosions, this was exceedingly common. Some of the sketches just exhibited by Mr. Negus rather suggested old perforations which had started again. It was certainly proved in the Four Years' War that when, about the beginning of 1916, the last drafts under the voluntary system reached the front the incidence of bleeding and suppuration in the front line units after a bombardment was enormously increased.

There was one further point about labyrinth lesions in concussion. He had an idea that Mr. Colledge had once suggested that they were progressive. His own experience rather supported this. He mentioned two cases of civil injury—labyrinth concussion—in which progressive labyrinthine deafness did seem to have occurred. One was in a contemporary of his own who, in 1905, in the public schools boxing competition at Aldershot, was knocked out and afterwards noticed a little deafness in his left ear. This had gradually progressed until the hearing on the left side was almost lost. But it had been a fairly slow process, extending over more than thirty years. The other was a similar case dating even further back. He thought that in these cases of labyrinthine concussion they should be on the look-out for a slow progressive high-tone deafness on that side.

Mr. W. M. Mollison recalled a case in which, in the last war, twelve men were subjected to a violent explosion in a munitions factory and were deafened ; two required operation. One of these furnished an example of the result of positive pressure because the incus, stained with gunpowder, was discovered lying loose in the antrum.

Mr. E. D. D. Davis said that with regard to rupture of the drum, the best thing was to leave the ear alone and keep the patient quiet in bed. When there was blood in the middle ear, the best position for drainage was the sitting one. If the patient was lying on one side drainage was not nearly so good. He had seen a number of examples of blood in the middle ear in cases of fractured skulls. Such blood rapidly disappeared.

Concussion deafness was a difficult subject. During the last war and also during the present bombardment of London the number of cases of internal ear deafness had been very small indeed. A distinction had to be made between concussion deafness and psychological deafness. With concussion deafness there were other cerebral symptoms and signs of severe injury.

On the subject of fracture of the labyrinth, cases which he saw in the last war of shell wounds around the ear were mostly fatal. He very much doubted whether a fracture through the labyrinth capsule actually occurred with survival of the patient. Mr. Colledge had spoken of fractures of the skull and involvement of the ear. The commonest by far of these fractures was through the roof of the tympanum and along the Eustachian tube and roof of the mastoid antrum. The other fractures through the posterior fossa and up to the petrous bone were mostly fatal in character. He had collected quite a number of these. Mr. Colledge had shown a drawing of a case recorded many years ago by Jonathan Hutchinson in which the fracture crossed the petrous bone along the anterior edge of the lateral sinus groove. Most of these fractures went through the cancellous bone around the labyrinth, and very rarely went into the labyrinth capsule. He had seen two cases post mortem of injury to the facial nerve in which the fracture crossed the apex of the petrous bone and divided the facial nerve as it bent downwards at the geniculate ganglion.

He had not observed progressive deafness, and it was astonishing to find so few cases of injury among those of internal ear deafness which one saw. He had questioned those patients on the subject of injury in the cases of internal ear deafness which were otherwise unexplained, but had seldom been able to elicit any history of it.

Dr. Hugo Frey agreed with Mr. Negus that the shape of the perforation of the tympanum depended largely upon the initial force exercised upon the part. It depended entirely on how the fissure ran—in relation to the direction of the fibres. He did not think that the traumatic ruptures of the membrane were a point of first importance. It was well known that they mostly healed after a short time. One should not interfere in these cases of traumatic rupture, and the most explicit instructions on that point should be given to everybody concerned. Later on, if the rupture showed no tendency to heal, there came a time when some intervention might take place. They were all aware that the simple traumatic rupture might not heal for six or eight weeks,

but cases were occasionally seen, especially those in which the rupture was of the larger type, in which up to five or even eight months or more elapsed without any visible attempts at closure. He was convinced that the reason why these cases did not heal was that which determined the non-healing of large perforations left over after chronic otitis, namely, that the epithelium from the outer surface of the membrane covered the border of the perforation and so prevented further union.

During the last war he took up a suggestion which had been made in some quarters that in cases like these it might be useful to attempt a slightly irritant treatment. This applied to cases in which large perforations still remained but with no danger of the original infection returning. The irritant treatment consisted in using a small probe with a piece of cotton-wool dipped in normal saline solution and with this one touched gently the border of the membrane in an endeavour to make it react. If that was not sufficient he took a small instrument such as a paracentesis needle and scratched off a little bit of the border of the membrane. In a number of such cases after this treatment the perforation did heal although otherwise no spontaneous healing could have been expected. Such a treatment should only be done by ear specialists.

In cases where heavier concussion of the skull had taken place some lesion of the internal ear was practically always present. The patient did not usually complain about this, nor could it be elicited with the ordinary tests, but it became evident when a complete functional test of hearing was carried out. Small differences in hearing capacity showed themselves and indicated that there was some slight lesion in the ear, which it was important to know about because these slight injuries which did not give much evidence at the beginning, might be the basis of progressive disease at a later stage.

He had found that in cases where there was what might be called a tangential injury from a bullet or fragment of shell meeting the side of the skull there was always a lesion of the internal ear if the fragment had touched the bone. Should a rifle bullet, for example, cause only a wound of the pinna, nothing happened to the internal ear, but as soon as the bone was met by the projectile, even if only superficially, a slight injury of the internal ear resulted and became evident as soon as one came to make detailed functional tests.

He fully agreed with the views of Voss and with those of others who had recommended that in cases where part of the temporal bone was fractured an extensive operation should be done as soon as there was the slightest sign of infection. It might be that one would have to modify this view after experience of the new disinfectants.

Mr. C. S. Hallpike asked whether Mr. Negus could say anything about the appearance of the tympanic lesions immediately after they had been sustained. He had not stated how long a time elapsed between the original injury and the appearance shown in his drawings. From the drawings he had got the impression that some mild ulcerative process had supervened upon the actual fissure or whatever it was that had occurred at the moment of damage.

Mr. C. Hamblen-Thomas mentioned the importance of the tympanic membrane in protecting the ear. He had had several cases of men employed on the anti-aircraft guns who had large perforations of the drum. They had complained bitterly of the noise, much more than the ordinary man did, and some of them had a little loss of bone conduction.

With regard to blast, speakers kept on referring to positive and negative pressures, applied, he presumed, directly to the external auditory meatus. But had anybody considered the effect of blast applied directly to the face causing a hyper-inflation of the middle ear with an accompanying negative blast in the meatus at the same time, producing some of those outward effects on the tympanic membrane which had been mentioned?

Otologists rarely considered the pinna of the ear, but if the pinna was injured it was a very difficult problem to replace it, involving a complicated grafting operation. In one case he had succeeded in using a tubular graft from the inner surface of the arm, fixing the arm to the head with plaster of Paris bandages. The position was quite comfortable and the grafting completely successful. Usually it was recommended to make such a graft from the back of the neck, but this was a difficult part to take, and he would recommend that for injuries of the pinna the inner surface of the upper arm should be considered.

Mr. R. J. Cann said that in the small number of cases of war injuries to the ear which he had so far seen as out-patients or as in-patients at the base hospital he had found some of them complaining a week or a fortnight after the injury, of great sensitiveness to slight sounds. They were grossly disturbed by the footsteps of people walking in the ward. One out-patient complained that whereas he used to amuse himself by tinkling on the piano he was now unable to do so because of the intense irritation which was set up. No mention had been made in that discussion of injuries to the contents of the middle ear.

In the cases which he had been able to test with a monochord shortly after the injury all had shown loss of high tones in some degree. He had asked all such patients to come back to see him at varying intervals in order that he might compare their monochord readings at a later date.

It was an interesting question as to why in all ruptures of the drum in which the edges could be seen the edges appeared to be everted. These injuries might be compared with those observed in peace time, as, for example, in injuries sustained in boxing by a blow from the open palm. All such injuries were splits and not tears, and it was rather suggestive that in these war injuries it might be the blast which caused the original split while the subsequent rarefaction tore the splits more widely open. In many of the cases which he had seen the tympanic membrane had completely disappeared and the contents of the middle ear as well.

Mr. Colledge had mentioned that a possible explanation for the concussion type of deafness was that the blast was transmitted by the incus. If members should come across a patient whom they knew to have suffered ear injury on one side as a result of blast and who happened to have a radical mastoid cavity on the other side, it would be interesting to find out whether internal ear deafness was discovered subsequently.

Mr. Lionel Colledge, in replying on the discussion, said that Miss Collier had made the interesting observation that buildings were a protection against blast. In the last war, however, it was observed that if soldiers received their injury in a dug-out, that is to say, a confined space, both ears were likely to suffer, whereas if they were injured in the open only one ear was affected or at any rate one ear was much more affected than the other.

Mr. Negus's diagrams of the tympanic membrane quite clearly proved one point which he had not mentioned, namely, that Shrapnell's membrane was never ruptured. The damage was always to the tense membrane. Therefore if a man came and claimed that the condition of his ear was due to explosion yet there was perforation of Shrapnell's membrane then one could be quite certain that the claim was without basis.

He fully agreed with what Mr. Watkyn-Thomas had said about progressive deafness. He was quite certain that he himself had seen it in many patients who had concussion deafness in the last war. It was something which corresponded to senile deafness, but it came on much earlier in life than normally.

Mr. V. E. Negus replied to one or two questions which had been addressed to him. In answer to Mr. Hallpike he said that he had not seen at first hand the cases he had described ; usually there had been at least twelve hours' delay and in many cases longer. In the majority of the military cases evacuated from France, more than one day had been taken on the journey and some had taken four or five days. But in the earlier cases that he had seen there was a remarkable absence of reaction. It was as if a hole had been punched through the membrane, leaving perfectly rounded smooth edges. He had not actually been able to see the everted edges. That, he thought, was also the appearance at the time of the injury. In pre-war civilian cases he had seen ruptured tympanic membranes of quite a different type. One boy who had sustained such an injury had been kicked in the ear by a companion while swimming, and the effect was to drive a column of water down the ear and detach part of the membrane from the tympanic ring. He had not seen anything like that in the civilian air-raid casualties or the military cases.

With regard to the contents of the middle ear, the cases which had come to him had not shown marked damage to the contents or to the ossicles, the injury being in that part of the membrane which mattered least.

He had had personal experience of traumatic deafness similar to that mentioned by Mr. Watkyn-Thomas. He acquired a high-tone deafness in the last war, his high-tone

limit remaining at about 5,000 vibrations by air conduction. He could not hear anything above that limit. He was told after the last war that he was going to be severely deaf. But the deafness was not progressive; air conduction remained at 5,000, bone conduction was practically normal. This corresponded with certain observations with the audiometer on children at Baltimore. The audiometer reading was practically normal up to about 4,000 or 5,000 vibrations, and then there was a sudden drop, with inability to hear high tones. This was of little moment in his own case, except that tinnitus occurred at 4,500, corresponding to the limit of high-tone perception by air conduction.

Section of Ophthalmology

President—A. J. BALLANTYNE, M.D.

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The Reflexes of the Fundus Oculi

PRESIDENT'S ADDRESS

By A. J. BALLANTYNE, M.D.

ABSTRACT.—The fundus reflexes reveal, in a manner not yet completely understood, the texture and contour of the reflecting surfaces and the condition of the underlying tissues. In this way they may play an important part in the biomicroscopy of the eye.

The physiological reflexes are seen at their best in the eyes of young subjects, in well-pigmented eyes, with undilated pupils and with emmetropic refraction. Their absence during the first two decades, or their presence after the forties, their occurrence in one eye only, their appearance, disappearance or change of character should suggest the possibility of some pathological state.

The investigation and interpretation of the reflexes are notably assisted by comparing the appearances seen with long and short wave lights such as those of the sodium and mercury vapour lamps, in addition to the usual ophthalmoscopic lights. Most of the surface reflexes disappear in the light of the sodium lamp, sometimes revealing important changes in the deeper layers of the retina and choroid.

The physiological reflexes, chiefly formed on the surface of the internal limiting membrane, take the forms of the familiar watered silk or patchy reflexes, the perimacular halo, the fan reflex in the macular depression and the reflex from the foveal pit. The watered silk or patchy reflexes often show a delicate striation which follows the pattern of the nerve-fibre layer, or there may be a granular or criss-cross texture. Reflexes which entirely lack these indications of "texture" should be considered as possibly pathological. This applies to the "beaten metal" reflexes and to those formed on the so-called hyaloid membrane.

The occurrence of physiological reflexes in linear form is doubtful, and the only admittedly physiological punctate reflexes are the so-called Gunn's dots.

Surface reflexes which are broken up into small points or flakes are pathological, and are most frequently seen in the central area of the fundus in cases of pigmentary degeneration of the retina or after the subsidence of a severe retinitis or retino-choroiditis.

A mirror reflex from the layer of pigmented epithelium or from the external limiting membrane is sometimes recognizable in normal eyes, especially in the brunette fundus. In such, it forms the background to a striking picture of the fine circumfoveal vessels.

Pathological reflexes from the level of the pigmented epithelium or of the external limiting membrane are also observed, and these often present a granular, frosted or crystalline appearance. They may indicate a senile change, or result from trauma or from retino-choroidal degeneration. Somewhat similar reflexes may sometimes be present as small frosted patches anterior to the retinal vessels.

Linear reflexes, whether appearing in annular form, as straight needles, as broader single sinuous lines, as the tapering, branched double reflexes of Vogt, or in association with traction or pressure folds, in the retina, are probably always pathological.

By the use of selected light of long and short wave lengths, it can be shown that intraretinal or true retinal folds may exist with or without the surface reflexes which indicate a corresponding folding of the internal limiting membrane. On the other hand, superficial linear reflexes of various types may occur without evidence of retinal folding.

Annular reflexes usually accompany a rounded elevation of the retina due to tumour, hæmorrhage or exudate, but may indicate the presence of rounded depressions; traction folds occur where there is choroido-retinal scarring, or in association with macular hole or cystic degeneration at the macula; pressure folds in cases of orbital cyst, abscess or neoplasm; and the other linear reflexes in association with papillo-retinal œdema, for

example, in retrobulbar neuritis, in hypertensive neuro-retinitis, in contusio bulbi and in anterior uveitis.

Punctate reflexes, other than Gunn's dots, are also pathological. They may occur as one variety of " fragmented " surface reflexes, or as evidence of the presence of some highly refractile substance, such as cholesterin or calcium carbonate, in a retinal exudate or other lesion.

It is characteristic of the pathological reflexes that they come and go and change their character according to the progress of the pathological condition. The linear reflexes in particular may change from one form to another, and may be finally transformed into surface reflexes of physiological character.

RÉSUMÉ.—Les reflets du fond de l'œil révèlent, d'une manière encore incomplètement comprise, le tissu et le contour des surfaces reflétantes ainsi que l'état des tissus sous-jacents. De cette façon ces reflets peuvent jouer une part importante dans la biomicroscopie de l'œil.

Les reflets physiologiques s'observent le mieux dans les yeux des sujets jeunes, dans des yeux bien pigmentés avec pupille non dilatée et avec réfraction emmétropique. Leur absence pendant les deux premières décades et leur présence après la quarantaine, leur apparition ou disparition ainsi que leur changement de caractère devraient faire penser à la possibilité d'un état pathologique.

L'investigation et l'interprétation des reflets sont notablement aidées par la comparaison des aspects vus au moyen de lumières à ondes longues et courtes, comme celles des lampes à vapeur de sodium et de mercure, en surplus des lampes ophtalmoscopiques ordinaires. La plupart des reflets superficiels disparaissent à la lumière d'une lampe à vapeur de sodium, révélant parfois des changements importants dans les couches plus profondes de la rétine et de la choroïde.

Les reflets physiologiques, généralement formés à la surface de la couche limitante interne, prennent les formes bien connues sous les noms de reflets " soie moirée " ou de reflets bariolés, de halo périmaculaire, ainsi que de reflet en éventail dans la dépression maculaire et de reflet fovéolaire. Les reflets " soie moirée " ou bariolés montrent souvent une striation délicate qui suit le dessin de la couche des fibres nerveuses; il se peut également qu'il y ait une texture granulée ou en grillage. Les reflets où ces indications de " texture " font entièrement défaut devraient être considérés comme pouvant être de nature pathologique. Ceci s'applique pour les reflets du genre " métal battu " ainsi qu'à ceux qui se forment sur la membrane hyaloïde.

L'existence de reflets linéaires physiologiques est douteuse, et les seuls reflets pointillés admissibles comme physiologiques sont ceux connus sous le nom de " points de Gunn "

Les reflets superficiels brisés en petits points ou en flocons sont de nature pathologique et s'observent le plus souvent dans la région centrale du fond de l'œil, dans les cas de dégénérescence pigmentaire de la rétine ou après la diminution ou la guérison d'une rétinite ou d'une rétino-choroïdite grave.

On observe quelquefois un reflet miroitant de la couche pigmentaire ou de la couche limitante externe dans l'œil normal, surtout chez les sujets à teint foncé. Dans ces cas le reflet est l'arrière-plan d'une saisissante image des vaisseaux fovéolaires.

On observe aussi des reflets pathologiques au niveau de la couche pigmentaire ou de la couche limitante externe. Ceux-ci ont souvent l'aspect granulé, givré ou cristallin. Ils peuvent indiquer un changement sénil, être le résultat d'un traumatisme ou de dégénérescence rétino-choroïdale. Des reflets à peu près semblables se présentent quelquefois sous forme de petites taches givrées antérieurement aux vaisseux de la rétine.

Les reflets linéaires, qu'ils soient annulaires, droits comme des aiguilles, en raies simples, sinueuses et plus larges, qu'ils prennent l'aspect des reflets effilés, doubles, ramifiés de Vogt, ou qu'ils soient associés avec des plis de traction ou de pression, sont probablement toujours de nature pathologique.

Par l'emploi de lumière choisie d'ondes longues et courtes, on peut démontrer que des plis intra-rétinaux ou rétinaux peuvent exister avec ou sans les reflets de surface qui indiquent un plissement de la membrane limitante interne. D'autre part, des reflets linéaires superficiels de types variés peuvent se produire sans évidence de plissement rétinal.

Les reflets annulaires accompagnent généralement une élévation arrondie de la rétine due à une tumeur, une hémorragie ou une exudation, mais ils peuvent également indiquer la présence d'une dépression arrondie; les plis de traction se rencontrent là où il y a cicatrisation ou en association avec le trou maculaire, ou bien encore avec la dégénérescence kystique de la macula. Les plis de pression se rencontrent dans les cas de kystes orbitaux, d'abcès ou de néoplasmes. Les autres reflets linéaires se présentent accompagnés d'œdèmes papillo-rétinaux, par exemple dans les névrites rétro-bulbaires, dans les neurorétinites hypertensives, dans les contusions du bulbe et dans les uvéites antérieures.

Les reflets pointillés autres que les points de Gunn sont aussi de nature pathologique. Ils peuvent se présenter comme une variété de reflets superficiels fragmentés, ou être un indice de la présence de quelque substance très réfractile, comme la cholestérine ou le carbonate de calcium, dans un exudat rétinal ou autre lésion.

Il est caractéristique que les reflets pathologiques viennent, s'en vont et changent leur caractère en accord avec le progrès de la condition pathologique. Les reflets linéaires, en particulier, peuvent changer d'une forme à l'autre et être finalement transformés en reflets de surface de caractère physiologique.

RESUMEN.—Los reflejos del fondo revelan de una manera todavía mal comprendida la textura y el contorno de las superficies espejeantes y la condición de los tejidos subyacentes. Así desempeñan un papel considerable en la biomicroscopía del ojo.

Se ven más claramente los reflejos fisiológicos en los ojos de personas jóvenes, en los ojos muy pigmentados a pupilas no dilatadas y a refracción emetrópica. Su ausencia durante los veinte primeros años de edad, su presencia despues de cuaranta a cincuenta años, su ocurrencia en un solo ojo, su aparición, desaparición, o cambio de carácter, indicarían la posibilidad de algún estado patológico.

Se facilita notablemente la busca y interpretación de los reflejos comparando los aspectos visibles en luz de longas y de cortas ondas como la de la lámpara con vapores de sodio o de mercurio, así como las luces oftalmológicas comunes. Desaparecen con la luz de la lámpara de sodio la mayoría de los reflejos superficiales, revelándose algunas veces alteraciones importantes en las capas algo profundas de la retina y de la coroides.

Los reflejos fisiológicos, que se hacen principalmente sobre la superficie de la limitante interna, presentan las formas de los bien conocidos reflejos salpicados o de muaré, del nimbo circunmacular, del reflejo de abanico en la depresión macular, y del reflejo foveal. Los reflejos salpicados o de muaré muestran a menudo una estriación fina que sigue la disposición de la capa de las fibras nerviosas; también pueden hacer ver una textura granular o cruzada. Deben considerarse quizá patológicos los reflejos en que faltan enteramente tales indicaciones de " textura ". Esto se aplica a los reflejos " de metal laminado " y a los formados sobre la llamada membrana hialoidea.

Es dudoso el ocurrirse reflejos fisiológicos lineales, y los únicos reflejos puntiformes reconocidos por fisiológicos son los llamados puntos de Gunn.

Los reflejos superficiales que se fragmentan en puntillos o en hojuelas son patológicos. se ven más frecuentemente sobre la zona central del fondo en casos de degeneración de la retina, o sobreviendo tras una retinitis o retinocoroiditis severa.

Un reflejo de espejo de la capa del epitelio pigmentado o de la limitante externa se puede reconocer a veces en los ojos normales, especialmente en los morenos. Constituye en éstos el fondo a un cuadro vívido de los vasos circunfoveales delgados.

También se observan reflejos patológicos a nivel del epitelio pigmentario o de la limitante externa que presentan a menudo un aspecto granular, mate o cristalino. Indicarían una alteración senil, o resultarían del traumatismo o de la degeneración retinocoroidal. Unos reflejos algo semejantes se muestran a veces como pequeñas placas mates delante de los vasos retinales.

Son probablemente patológicos todos los reflejos lineales, o sean anulares, o tomen formas de agujas rectas o más anchas líneas tortuosas, o los dobles reflejos afilados y brancados de Vogt, o asociados con plegaduras de tracción o de presión en la retina.

Usando luces escogidas de ondas largas o cortas se puede demostrar la existencia de plegaduras intrarretinales o verdaderamente retinales en compañia o no de los reflejos superficiales indicativos de una plegadura correspondiente de la limitante interna. En cambio es posible el ocurrirse reflejos lineales de superficie sin evidencia de plegaduras retinales.

Los reflejos acompañan en general a una elevación redonda de la retina debida a tumor, hemorragia o exudados, pero pueden indicar la presencia de depresiones redondas; las plegaduras de tracción se ocurren donde hay cicatrización coroidorretinal, o asociados con el agujero de la mácula o la degeneración quística macular; las plegaduras de presión en casos de quiste, absceso o neoplasia orbitales; y los demás reflejos lineales asociados con la edema papilorretinal, por ejemplo en neuritis retrobulbar, neurorretinitis hipertenso, contusio bulbi y uveitis anterior.

También son patológicos los reflejos puntiformes con excepción de los puntos de Gunn. Pueden ocurrirse como una variedad de los reflejos superficiales " fragmentados " o comprobar la presencia en un exudado retinal u otra lesión de alguna substancia de alta refractividad como la colesterina o el carbonato de calcio.

Es característico de los reflejos patológicos de ir y venir y de alterarse según los progresos de la condición patológica. En especial pueden los reflejos lineales cambiarse de una a otra forma, y se pueden transformar finalmente en reflejos superficiales de índole fisiológica.

THE light reflexes from the fundus oculi present an interesting series of phenomena, which, as aids to the interpretation of certain fundus pictures, deserve more attention than is usually devoted to them.

There are many ophthalmoscopic appearances, both normal and pathological, of which we cannot give a satisfactory histological explanation ; indeed there are some which, from their very nature, are unlikely to receive such an explanation, partly because they cannot survive the fixation and other manipulations necessary for histological examination.

Among these are the fundus reflexes, which depend for their occurrence on normal or abnormal tissue relationships which are likely to be profoundly altered in the course of histological preparation.

The clinical study of the reflexes therefore serves the double purpose of throwing light on the nature and cause of the reflexes themselves, and of employing them as part of the biomicroscopy of the retina, choroid and adjacent structures.

After all, the ophthalmoscope, within the limits of available magnification, performs the function of a microscope. We obtain magnifications ranging from the five diameters of the indirect method, to the fifteen diameters of the direct method or even the forty diameters obtained with the Gullstrand ophthalmoscope. We can vary the intensity, colour and incidence of illumination, and even obtain something approaching to the so-called " optical section " given by the slit-lamp.

The *general principle* governing the occurrence of the fundus reflexes is that every surface separating two media of different indices of refraction—air and cornea, vitreous humour and retina—reflects light in two ways : (1) diffusely or irregularly, and (2) in a regular or specular manner. One or other of these may predominate, but our knowledge of the structure of any reflecting object is derived from a combination of these two forms of reflection.

Most objects are rendered visible by irregular reflection of the incident light. Regular, or specular, reflection reveals both the contour, and the finer surface detail or texture. We are familiar with this in the mirror reflexes of the cornea, where the image of the light source may reveal a normal contour with alteration of texture (the steamy cornea of interstitial keratitis) or normal surface texture with disturbance of contour (the smooth faceted cornea following healing of an ulcer). The fundus reflexes give similar indications.

When the reflecting surface lies in front of a poorly reflecting background (as in the case of the retina backed by a deeply pigmented epithelial layer) regular or specular reflection from the retinal surface predominates ; while the presence of a strongly reflecting background, such as the sclera in the albino fundus, tends to obscure the regular surface reflection.

As Kreiker (1924) pointed out, the forms assumed by these reflexes depend on the fact that the retina, in addition to its concave reflecting surface, presents many secondary curvatures—spherical, cylindrical or toric—with varying radii of curvature, all producing their individual and independent reflections ; and from a study of the form, size and behaviour of the reflexes we can infer the character of the reflecting surfaces. If, for example, we take the very obvious mobile surface reflexes, the manner in which they follow the movements of the ophthalmoscope mirror, and vary in size and shape, indicates that they are formed on a surface with irregularly concave facets ; while their behaviour when they come into relation to one of the larger retinal vessels shows that the vessel raises the reflecting surface into a ridge of cylindrical form, merging gradually, on each side, into the general contour of the fundus. In this way the reflexes reveal the contour of the surface at which they are formed, but, as we shall see, they also reveal the texture of the surface.

It is not strictly accurate to draw a distinction between contour and surface texture. The latter is only one aspect of the former, the finer markings being merely small-scale variations of the surface contour, but the distinction is a convenient one, and applicable to the conditions in the fundus oculi.

The recurrence of certain forms of surface reflex under both physiological and pathological conditions, for example, irregular lines passing from disc to macula or following the course of the vessels and nerve fibres from the disc, suggests that there is something in the structure of the retina which predisposes it to form ridges or folds along such lines. Fig. 1 photographed from a post-mortem specimen which had been fixed by intra-ocular injection of formalin shortly after death, shows in a crude but convincing way that such a predisposition does exist. It must be admitted of course that the reflexes we are discussing do not always follow such a pattern.

The retinal reflexes are images of the light source, namely, the mirror of the ophthalmoscope, and the colour and brilliance of the reflexes depend on the nature of reflected light and on its intensity. Other factors which influence the brilliance of the reflexes are the difference between the indices of refraction of the two media, the physical structure of the reflecting tissue and the optical form of the reflecting surface.

For descriptive purposes one may suggest the following classification of the light reflexes seen in the normal eye:—

The Physiological Fundus Reflexes

(1) *Patchy reflexes.*—(*a*) From the internal limiting membrane. Including the watered-silk reflexes, the perimacular halo or nimbus, the macular fan reflex and the reflex from the foveal pit; (*b*) From the deeper layers (pigmented epithelium or external limiting membrane).

(2) *Linear reflexes.*—(*a*) Annular reflexes. Including the annular or arcuate reflex of Weiss; (*b*) Needle reflexes.

(3) *Punctate reflexes.*—Gunn's dots.

(1) *Patchy reflexes.*—I speak of these reflexes as "patchy" because commonly their shape is round, quadrilateral, polygonal or irregular, as if formed on a shallow concave reflecting surface. As the classification shows they may proceed from at least two different

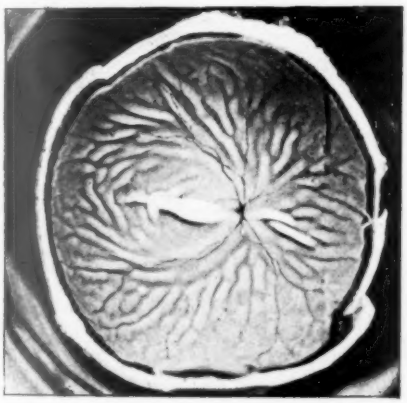

FIG. 1.—Posterior segment, showing formation of retinal folds. Specimen fixed with intra-ocular formalin shortly after death.

levels: from the surface of the retina, and from the retinal pigment layer, or external limiting membrane.

(*a*) *Reflexes from the internal limiting membrane.*—These are the most common of all the fundus reflexes (figs. 2, 3, 4, 5). They can be seen at their best in young persons with a rather dark fundus, with a small pupil and with emmetropic or almost emmetropic refraction. The reasons for these variations are not completely understood. If we accept the view that these reflections take place at the internal limiting membrane, their disappearance in the fourth and later decades seems to imply that with advancing years the retinal contour is smoother than in childhood and adolescence. The greater tortuosity of the retinal vessels in the young eye would be in keeping with such a view. The somewhat reduced brilliance of the reflexes with the dilated pupil may be due to the greater amount of scattered light. It is not difficult to understand why they are brighter against the dark background of a well-pigmented retina and choroid.

One of the most striking characteristics of the surface reflexes is their transience and variability. On the slightest movement of the ophthalmoscope, they appear to flit rapidly

from point to point, appear and disappear, or undergo incalculable changes of shape. Their ophthalmoscopic appearance is so dependent on these quick changes that it is impossible to reproduce them satisfactorily in a drawing. In black and white reproductions of fundus photographs the presence of these reflexes adds to the difficulty of interpretation.

Although the shapes of the glistening patches seem to vary in a fantastic fashion, we can recognize certain recurring forms (seen in figs. 2, 3 and 4); round or polygonal patches in the intervals between the vessels, bands of varying width which lie close to the blood-vessels but without making contact with the blood column, and incompletely circu-

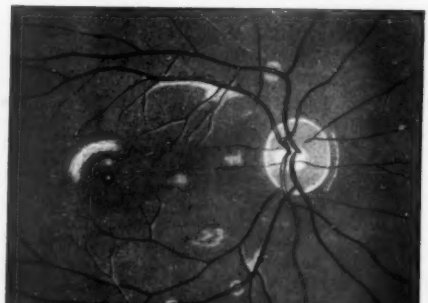

FIG. 2.—Composite picture showing different forms of surface reflex.

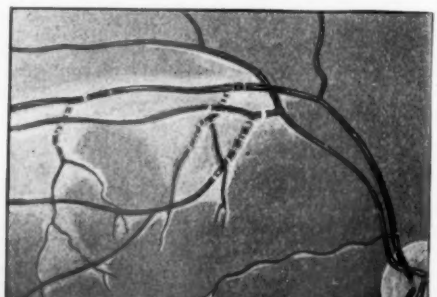

FIG. 3.—Surface reflexes along and among the retinal vessels.

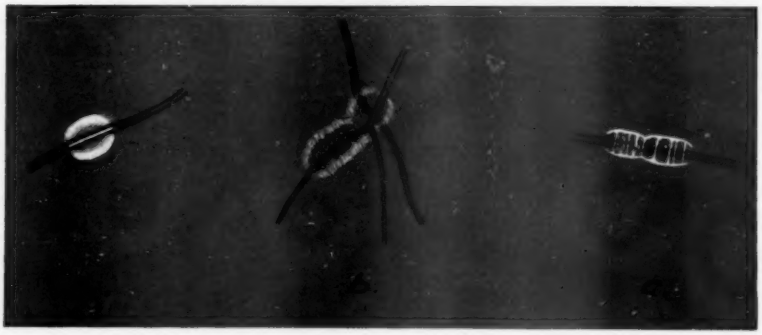

FIG. 4.—Reflexes in relation to retinal vessels. (*a*) Annular reflex and bright axial streak. (*b*) Reflex with nerve-fibre striation. (*c*) Reflex with striæ crossing the vessel.

lar or ring-shaped patches some of which sit astride the blood-vessels. On the vessels themselves, especially in association with the ring-shaped reflex, there is often a brilliant reflex along the axis of the vessel like a central light streak, more scintillating and more superficial than the relatively immobile axial streak (fig. 4*a*).

In cases where the surface reflexes are especially well seen, they may form delicate lacy lines crossing the blood-vessels and linking together the surface reflexes on either side (fig. 3, fig. 4*c*).

The surface reflexes in general are seen most distinctly in the central area of the fundus, around the macula, above and below the disc, less markedly at the nasal side of the disc

and scarcely at all in the more peripheral parts of the fundus. With certain exceptions the reflexes move in the same direction as the incident light, that is, in the direction of rotation of the ophthalmoscope mirror.

Watching the behaviour of these reflexes as the light is moved across the fundus, it is evident that they are formed in front of the vessels and in front of the nerve-fibre layer, and it is generally agreed that they are reflections from the membrana limitans interna. Usually they seem to come from an irregular wavy and structureless membrane, but it is often possible to recognize an extremely delicate striation in the reflex patch (fig. 2, fig. 4*b*). As a rule this striation, when visible, follows the direction of the nerve fibres, a feature which is chiefly seen in the papillo-macular area and around the macula. More rarely the patch has a striation concentric with the circumference of the disc, or at right angles to the direction of the blood-vessels and nerve fibres, sometimes the reflex is striated in two directions at right angles to each other, giving a texture like the warp and woof of a fabric, or it may have a finely granular or mosaic texture. These striations within the patch, are, of course, an indication of the texture of the reflecting surface and are a different thing from the linear surface reflexes to be described later. The patchy *form* of the surface reflex is an indication of the *contour* of the reflecting surface, while the *striation* reveals its *texture* or finer structure.

I have seen no reference elsewhere to the nerve-fibre striation of the surface reflexes; but it is often very definite, and deserves some attention. The size of any one reflex patch being small, one does not see an extensive display of the nerve-fibre pattern in one position of the mirror, thus contrasting with the view of the nerve fibres themselves, which are often visible over a wide area through diffuse illumination; but if the luminous patch is moved over the fundus, from disc to macula and around the latter, one can often trace the course of the nerve fibres very completely in those situations.

Where the striation follows the course of the nerve fibres, we are tempted to infer that at such points the membrana limitans interna is closely applied to the nerve-fibre layer, and, *per contra*, that when the reflection shows no striation the reflecting membrane is in less intimate contact with its background. This view is supported by the fact that the finely striated patches tend to be larger and of more geometrical form than the unstriated, the latter giving one the impression of being produced on a more corrugated or irregular surface. One cannot escape from the impression that the reflecting surface in the latter case is somewhat more loosely connected with the nerve-fibre layer than at points where there is a definite striation. The difference between the striated and the unstriated reflexes may have some pathological significance.

The striated reflex has to be distinguished especially from two other appearances, namely, the nerve-fibre pattern and the needle reflexes to be referred to later. The nerve fibres are not seen by specular reflection but by irregular reflection, and have a matt appearance. They are very clearly visible, especially at the upper and lower temporal borders of the disc, in papilloedema, and even in non-pathological cases, although in normal eyes they can be traced more easily by the use of monochromatic light—the sodium or mercury vapour lamps. The fibres are arranged in bundles of varying width, usually about the width of the perimacular venules, and there is a certain interlacing of the adjacent bundles so that they do not form a system of strictly parallel lines. The striated reflex, on the other hand, is a mirror reflex. The lines are much finer and more closely set than those of the nerve-fibre bundles, and are more strictly parallel.

The needle-like reflexes are also mirror reflexes, but they consist of individual bright lines, straight and parallel to each other, or diverging, as at the nasal side of the disc. The individual lines vary in different cases, but are usually about the width of the nerve-fibre bundles, and the intervals between them are at least as wide as, usually much wider than, the lines themselves.

Theoretically, specular reflections may occur at every surface of separation between the successive strata of vitreous, retina, choroid and sclera, and, while those from the internal limiting membrane are the most conspicuous, there are others. Some, I believe, are formed on a plane even anterior to that of the membrana limitans interna, probably, as Vogt suggests, from the so-called hyaloid membrane. They are more formless, less brilliant and more ghostly than the others, and give one the impression of being formed on a quite textureless surface.

The perimacular reflex.—In the indirect method of ophthalmoscopy this is the most prominent of all the reflexes. It takes the form of a grey luminous nimbus or halo which

surrounds and defines the macula. Its inner boundary, towards the fovea, is sharply defined, while its outer border fades more gradually into the surrounding red fundus. The width of the halo is not equal at all points in its circumference, and varies somewhat with movements of the eye or of the light beam (fig. 5).

Examining by the direct method, with unfiltered light, we seldom see anything like a complete perimacular reflex. In its place we find patches of the mobile surface reflex which approach the macula from different directions according to the movements of the mirror, but cease rather abruptly when they reach the outer limit of the macular depression. As already explained, these patches may show striation, usually concentric with the macula, or one may meet with the unusual form I have described as a " needle " reflex or " aurora " consisting of bright needle-like radiating streaks which can be made to move up to the edge of the macular depression but not within the macula itself (fig. 6).

The foveal reflexes.—These reflexes are usually present whether the direct or the indirect method is used, but vary in form according to variations, physiological or pathological, in the fovea.

The most common form of foveal reflex is either a point of light or a complete or incomplete ring at the centre of the fovea (figs. 2, 5, 6). It is supposed to form on the side of the foveal pit.

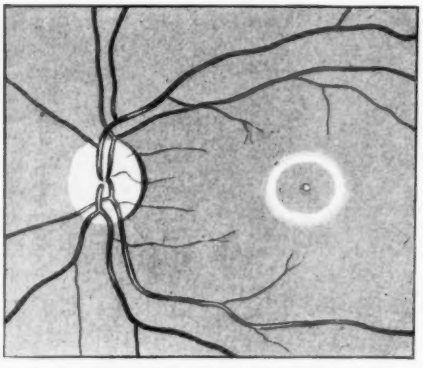

FIG. 5.—Perimacular reflex and reflex from foveal pit.

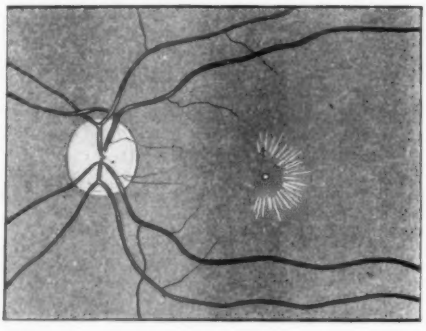

FIG. 6.—Perimacular " needle " reflex.

Sometimes it has associated with it a wisp of light, narrow towards the foveal centre and widening towards the margin of the macula—the " fan " or " comet " reflex of Gunn (1888) (fig. 7). The fan reflex most commonly radiates from the central foveal reflex towards the nasal border of the macula, but it may radiate towards the temporal side or elsewhere. In exceptional cases it forms a very vivid beam of light which seems to project from the central point into the vitreous and, with movements of the mirror, swings round in all directions pivoted on the centre like a searchlight. This projecting form of the foveal reflex was first described by Marcus Gunn. The form of the fan reflex, as of all the surface reflexes depends on the contour of the reflecting surface. It suggests a shallow conical depression, sometimes symmetrical, sometimes tilted slightly in one or other direction.

It is interesting to note that when the mirror is moved in any meridian towards the centre of the macula, the patchy perimacular reflex and the fan reflex within the macula move in opposite directions. The former moves *with* the mirror and halts at the margin of the macular area, while the latter moves *against* the mirror and meets the perimacular reflex at the boundary, where they merge. When the mirror movement is reversed, the fan reflex moves as it were down the slope of the macular depression, growing shorter

until it merges and disappears in the foveal reflex, while the perimacular reflex moves out into the surrounding retina (fig. 7).

(*b*) *Reflexes from the pigmented epithelium of the retina.*—Coming now to the surfaces deeper than the internal limiting membrane; in many eyes, especially if deeply pigmented, even with the ordinary ophthalmoscopic illumination, a shagreen-like reflection can be obtained from the retinal pigmented epithelium. This is usually seen only in the macula and its immediate neighbourhood, no doubt because in this area the retina is thinned and the pigmented epithelium is darker than elsewhere. While the average macula, whatever be the intensity or mode of incidence of the light, shows the fovea as a dark red spot in the midst of a lighter orange area, the fine macular vessels being difficult to make out for lack of contrast with the background, the specular reflection from a well-pigmented epithelial layer shows up a greyish ground almost like that of a semi-polished steel plate, against which the circumfoveal vessels down to their extremely fine terminal twigs, stand out with great clearness. In this view we may succeed in seeing the terminal loops, but usually the vessels seem to end in a dendritic pattern.

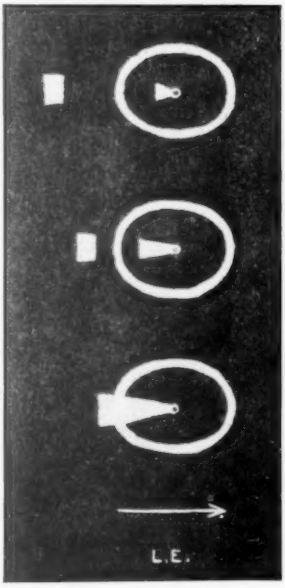

FIG. 7.—Macular and foveal reflexes, changing with movements of the mirror.

I have been interested to find that this picture is best obtained with the twin-beam ophthalmoscope. If the prisms are adjusted to give two slightly divergent beams divided on the fundus by a dark line about the width of a main retinal artery, and if this dark line is made to cross the macula by slight oscillations of the mirror, the deep retinal reflex is particularly well seen, forming a lustrous background to the circumfoveal vessels.

The mirror reflex from the pigmented layer differs in several respects from the surface reflexes. It is less luminous. It does not form a sharply defined patch, but gives one the impression of the image of the light source formed on a somewhat dull concave surface of regular curvature, in contrast with the watered silk reflexes formed on a more lustrous surface of irregular contour—the internal limiting membrane. This deep surface reflex often presents the appearance of a fine mosaic pattern, and this lends some support to the view that the pattern of the pigmented epithelium may be visible with the ophthalmoscope.

I may be wrong in attributing this deep reflex to the pigment layer; it is not impossible that it may be formed on the external limiting membrane; but it certainly comes from a surface deeper than the finest visible retinal vessels.

(2) *Linear reflexes.*—While some sort of classification is helpful for purposes of description, it cannot be entirely logical, since we do not yet know the whole histological meaning of these phenomena. Linear reflexes might be grouped along with the mobile surface reflexes, since they are formed on the same plane, and resemble them in their brilliance, in their scintillating and variable character, and in the manner in which they follow the movements of the ophthalmoscope. They also occur in the same areas of distribution, namely in the neighbourhood of the papilla and macula and in the papillo-macular area, but their forms are distinctive, and they probably have a special histological significance.

(*a*) *Annular reflexes.*—The only form of annular reflex which can be regarded as physiological is the so-called Weiss reflex. This, in its most common form, is a single, irregular, curved line running for some distance concentric with the nasal border of the disc, and about half a disc's breadth from it (fig. 8); but the reflex may assume many different

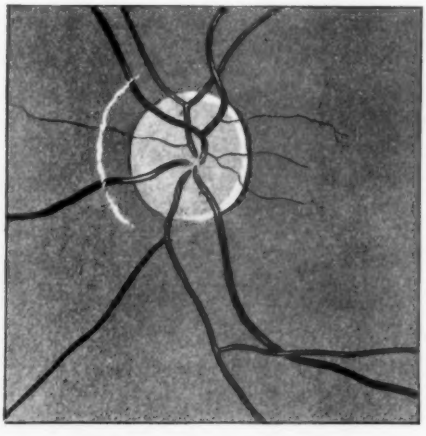

FIG. 8.—Weiss's arcuate reflex. Common type.

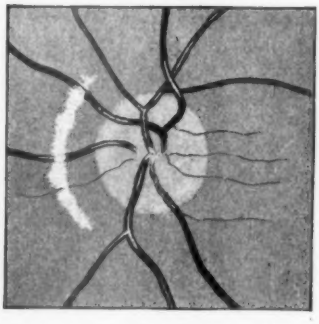

FIG. 9.—Weiss's arcuate reflex. Broad, striate type.

forms, for example, it may be a zone of irregular width presenting a striation in the direction of the nerve fibres (fig. 9). It shifts a little towards and away from the disc with movements of the ophthalmoscopic mirror, and seems to be formed on the internal limiting membrane of the retina.

Weiss supposed this reflex to be peculiar to myopia, and doubtless it is more conspicuous and more familiar in that condition when the ordinary form of illumination is employed; but this reflex can be seen in other conditions of the refraction, and, like the other surface reflexes, its form depends on the contour of the reflecting surface. In this case the nerve fibres, in leaving the disc, rise and fall again, thus causing the formation of a convex ridge parallel to the disc margin. The reflex is apparently formed on the concave surface between the summit of the ridge and the general retinal level. The fact that the gradient is steeper on the nasal side of the disc than on the temporal side explains the greater visibility of the phenomenon on the nasal side.

(*b*) *Needle reflexes.*—I use the term "needle" reflexes to describe a variety of the mobile surface reflex which I have observed in the circumfoveal and circumpapillary regions. The distinguishing feature of these reflexes (fig. 6) is that they consist of thin, straight, elongated, needle-like, glistening streaks arranged radially to the macula or

disc, and reminiscent of the aurora borealis, especially as they seem to shoot out radially from a central point when the mirror of the ophthalmoscope is oscillated in a direction corresponding to their long axis. They resemble the patchy surface reflexes in their mobility, but, apparently they indicate a radial wrinkling of the membrana limitans interna. They have the width of the finer perimacular vessels, and are therefore very much narrower than the double contour lines of Vogt to be referred to later. They are much narrower also than the familiar traction folds, and the intervals between them are wider than the lines themselves. They may occur in groups but always as discrete lines which do not coalesce to form patches.

I am not prepared to say that this form of reflex is physiological, but in one case where it was seen around the macula, in a boy, 4 years of age, of dark complexion (hair, irides and fundi) there was no suspicion of any pathological condition. In most of my observations, however, the cases were definitely pathological.

(3) *Punctate reflexes.*—Minute glistening points or punctate reflexes have been described from time to time, and, although the details with regard to size, distribution, &c., vary, it is doubtful how far these can be considered as different phenomena.

The first, or one of the first, descriptions was that given by Marcus Gunn (1883). His description runs: "Very minute yellowish-white shining dots for some distance around the disc, especially to the nasal side and below. In distribution these dots are remarkably equidistant from each other, and are situated anteriorly to the largest retinal blood-vessels,

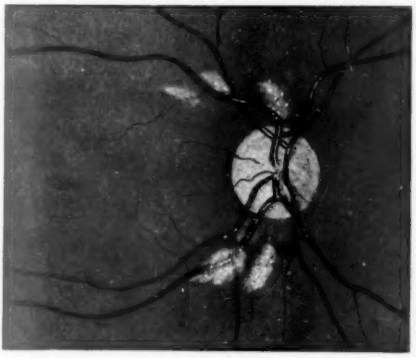

FIG. 10.—Gunn's dots. (R.)

each being less than one-fifth of the diameter of a large vessel. This appearance is most easily seen when the light is thrown somewhat obliquely on the part of the retina to be examined; the dots will then be seen to stand out well near the image of the border of the flame." These dots, usually called "*Gunn's dots*", are also referred to as "Crick" dots, as they were first discovered by Gunn in several members of a family of that name.

Adams Frost (1896) also described what he called "metallic dots" which occurred singly and might be found in any part of the fundus. He likened them to particles of mercury. Subsequent authors seem to have applied the term "Gunn's dots" to other and different appearances. Thus Weeks (1911) described them as situated *in* the macula, and said that they might be almost black, light-coloured or glistening. Beard (1910) referred to them as small red-orange dots in the macula, due to the absence of pigment. (Probably these would now be referred to as drusen.)

De Schweinitz, in his textbook, speaks of Gunn's dots as occurring within the macula and being either dark or light.

Kreiker (1929-30) says that they are usually seen in the largest numbers over the fovea, but not *in* the fovea, and that they are independent of the surface reflexes.

Leslie Paton (1918), a pupil of Marcus Gunn's, gave a description of the character and situation of the dots which should make this confusion unnecessary. The illustration (fig. 10) shows some of the principal features of the dots described by Gunn, and it

will be seen that in this case they were conspicuous in the region below the disc. The dots are of uniform size (about the diameter of the smallest visible vessels) and shape (somewhat oval, the long axis being in the direction of the blood-vessels or nerve fibres) and they are quite superficial (lying sometimes definitely in front of the retinal vessels). They show no tendency to coalesce. They seem to run in rows, the intervals between the dots in a row being smaller than the intervals between the rows. Like the other surface reflexes, they are often best seen in the penumbra of the illuminated area. Contrary to Kreiker's experience, but consistently with Gunn's description, the dots are definitely associated with the surface reflexes, in the sense that when one follows the latter as they move with movements of the mirror, they seem at certain points to pick up the glistening dots, and a group of these will suddenly shine out, as brilliant dots in the midst of the somewhat less brilliant patch of the surface reflex. One may compare this to the appearance seen when a searchlight picks up an aeroplane as a light speck against the less luminous reflection from a background of cloud, or a white cottage against a more dimly illuminated hillside.

One sees these punctate reflexes very frequently and their occurrence is not limited to any one area. They are most commonly seen around the disc and along the line of the nerve fibres radiating up and out, and down and out, from it. It may be assumed that they represent the "high lights" from minute elevations of the reflecting surface, probably the internal limiting membrane; although Dimmer (1921) thought that they represented small concavities produced by the footplates of Müller's fibres. No histological demonstration of their true nature has been given. The view that they may have some intimate relation with the nerve fibres is supported by the fact that, as indicated in the diagram, they often run in series along the line of the nerve fibres.

Another observation, just recently made, lends further support to this view. A boy, 14 years of age, had a concussion injury in the right frontal region, followed by optic atrophy with loss of vision in the upper half of the corresponding field. In monochromatic ophthalmoscopy the lower half of the fundus showed a faint nerve-fibre pattern and no Gunn's dots, while both were very well seen in the upper half of the retina.

The Pathological Fundus Reflexes

How far can we expect a study of the fundus reflexes to take us in the diagnosis of pathological changes? The answer to this question necessitates a knowledge of the variations which we recognize to be within normal limits; and, as we have seen, these are very wide, and still to some extent unexplained.

In the first place, we know something of the conditions which determine the presence or absence of the reflexes. The surface reflexes are less conspicuous and more often entirely absent in the third and fourth decades and thereafter are only seen in exceptional cases. They are, as a rule, absent in the higher degrees of myopia and hypermetropia, and are more frequently absent, or faintly visible, in the blonde fundus than in cases with deeper pigmentation. In cases where, owing to age, refraction and pigmentation, we would not expect to see these reflexes, they may be rendered visible by the use of ophthalmoscopy with red-free light.

The absence of the reflexes in a case where they would naturally be looked for (for example, in a child of normal pigmentation) or their presence where unexpected, say in the later forties, will suggest an abnormal state; and if the abnormality is found in one eye alone we must look upon it as probably pathological. Disappearance of the reflexes, reappearance when they have been absent, and alterations of their character, are all suggestive of pathological states, and may give valuable information regarding the progress of the disease.

The fundus reflexes described as physiological are subject to many variations which have not been explained and which leave one in doubt as to the limits of the normal and the varieties which are to be considered pathological. For example, the foveal reflex is often absent in cases without visual defect, or other evidence of abnormality. The circumfoveal and fan reflexes are not always to be seen. Gunn's dots are probably more often absent than present, and yet seem to have no pathological significance. Striation and other textural markings in the patchy surface reflexes are common, but not invariably present. The rarity of some forms, for example Gunn's fan reflex, has caused them to be looked upon as pathological by their earliest observers.

A feature of many of the pathological reflexes is their tendency to undergo changes in the course of the pathological process, changes which may point to an increase or to a resolution of the underlying lesion.

The following offers a suggested classification of the pathological fundus reflexes :—

(1) *Patchy reflexes.*—(*a*) From the internal limiting membrane ; including the beaten metal reflex and fragmented reflexes. (*b*) From the deeper layers (external limiting membrane or pigmented epithelium)—metallic, crystalline or frosted in character. (*c*) From the "hyaloid" membrane.

(2) *Linear reflexes.*—(*a*) From the internal limiting membrane ; including annular reflexes, needle reflexes, double contour reflexes. (*b*) Intraretinal lines. Traction and pressure folds.

(3) *Punctate reflexes.*

(1) *The patchy reflexes.*—The shapes of the normal surface reflexes vary enormously and change constantly with movements of the ophthalmoscope, and this sometimes makes it difficult to draw the line between the normal and the abnormal ; but familiarity gives one a general idea of the more expected forms of reflex and of the types that are a departure from the normal.

(*a*) *From the internal limiting membrane.*—Under physiological conditions the surface reflexes, whatever their shape, often present a striated or granular texture, and the normal eyeground always shows a characteristic granular or stippled character. A form of reflex which I venture to call a "*beaten metal*" *reflex,* is sometimes seen in and around the macula under pathological conditions. The form of this reflex indicates the presence of shallow and irregular elevations of the surface, its lack of "texture" suggesting that the anterior limiting membrane is detached from the underlying retina, and its comparative lack of luminosity combined with loss of the normal stippling of the background seem to indicate the presence of a somewhat turbid fluid behind the internal limiting membrane. This reflex may occur at an age when the surface reflexes are normally absent, and is associated with such states as shallow detachment of the retina and the central retinitis or retinal oedema which accompanies an anterior uveitis.

A bright reflex from the foveal pit is not invariably present in normal eyes, but its absence, especially from one eye only, should arouse suspicion.

The nimbus-like perimacular reflex is formed on the glacis surrounding the macular depression. In pathological conditions the reflex may be broken up or fragmented, and the area enclosed by the reflex may be contracted or enlarged, or may assume an irregular outline. A study of the macular reflexes may therefore give valuable help in diagnosis.

Kreiker has seen cases of amblyopia in which the reflex ring was small and round, suggesting a small flat depression. One has more frequently seen cases in which it was much larger than usual. Thus, in two brothers, aged respectively eleven and nine years, suffering from symmetrical macular disease, with some loss of central vision, the macular depression as indicated by the size of the reflex ring measured about two p.d.s in the horizontal and one and a half p.d.s in the vertical diameter. This was associated with a striking change in the reflexes within the macular area, which was best seen in the right eye of the elder boy in which the disease was most advanced. The fan reflex could be elicited in practically all meridians of the macular area, moving as usual scissors-wise in relation to the perimacular reflex, but in a fragmented form.

The fragmented reflexes referred to in the classification above arise from the internal limiting membrane but are much smaller than the reflex patches seen in the eyes of young persons, their diameter being roughly that of a main blood-vessel, their shape polygonal and their margins sharply defined. They are seen principally in cases of pigmentary degeneration of the retina, or where a severe retinitis or chorioretinitis has subsided, leaving atrophic changes, with, presumably, numerous irregularities in the surface contour of the retina. In some cases fragmentation of the reflexes is associated with retinal œdema or exudate. Here, no doubt, the traction of Müller's fibres helps to determine the form of the surface. Owing to the nature of the background the reflexes will be less brilliant than in the atrophic conditions, and the normal fundus stippling will be concealed by the infiltrated retina, as in the case of the beaten metal reflex already referred to.

An interesting example of the diagnostic value of the surface reflexes was the case of a young woman 27 years of age, in whom V.A. of $\frac{6}{12}$ with a central scotoma in one eye led to the provisional diagnosis of retrobulbar neuritis. In the central area of the retina

there were irregular, fragmented, and unexpectedly numerous surface reflexes, absent in the fellow eye. With the sodium lamp these reflexes were eliminated, and there was revealed some mottling of the macular eye-ground which led to a revisal of the diagnosis. In about two weeks there was more definite evidence of a retino-choroiditis. A year later, vision had returned to $\frac{6}{6}$, there were more gross pigmentary changes in the choroid, and no reflexes were now seen.

It is, I think, in the macula that the study of the reflexes is most likely to prove of value in diagnosis and prognosis. Disorders of macular vision often occur with little or no visible objective change, and here slight abnormalities of the reflex phenomena may come to our aid. One's attention has often been drawn to the possible presence of macular changes by the observation of the beaten metal, fragmented, annular or other pathological reflexes. And one could cite a number of cases in which interesting transformations of the reflexes were seen, as in the case just quoted. The interpretation of these changes is not easy, but they will certainly repay further study.

(*b*) *The metallic, crystalline or frosted reflexes* from the deeper layers of the retina (the pigmented epithelium, or the external limiting membrane) vary greatly in size, from a few pin-points to an area larger than the disc, and their shape may be quite irregular. The appearance is usually that of a fractured metallic surface presenting minute glistening or even iridescent facets, though it may be more like the flakes of iron pyrites embedded in slate or coal, or it may resemble the frosting produced by powdered glass. It is difficult to suggest the nature of the reflecting surface, but it is definitely deeper than the retinal vessels, which can be seen silhouetted against the lustrous background.

One has seen this form of reflex in small patches in the fundi of elderly persons, where it might be described as a senile change ; within the pathological area in cases of familial macular degeneration ; in the late stage of a severe pregnancy retinitis, and, in its most extensive distribution, in a case of blunt injury to the eye with circumpapillary pigmentary changes due to rupture of the posterior ciliary arteries. In the case of the two boys with familial macular dystrophy to which I have already referred, the floor of the abnormally wide macular depression presented a bright golden reflection from numerous points or groups of points which might be compared to the reflection from a crystalline metallic surface. While the form of the macular reflexes indicated the deformation of the retinal surface, the metallic character of the reflexes signified a qualitative change in the tissues which provided the reflecting surface. The correlation of the ophthalmoscopic and histological appearances in such a case, may in the future reveal the nature of the change. There is abundant histological evidence of the occurrence of distortion in the retinal and choroidal planes, and of qualitative tissue changes, such as glial proliferation, laminated epichoroidal deposits, "pannus" of the lamina vitrea, deposits of calcium salts and cholesterin crystals ; but so far as I am aware, none of these has ever been identified as the histological representation of the crystalline or metallic fundus reflex. Although, in the great majority of cases these metallic or crystalline reflexes definitely come from a plane deeper than that of the retinal vessels, I found, in one case—an elderly man—a somewhat similar reflex superficial to the retinal vessels and situated in the papillo-macular area. It took the form of two or three round patches, each about one-fifth of the diameter of the disc, which glowed with a golden crystalline reflection as the light passed over them.

(*c*) *From the hyaloid membrane.*—The reflexes presumed to be formed on the hyaloid membrane or condensation layer of the vitreous, have been observed in cases of anterior uveitis. Some of the reasons for the assumption that they form in front of the internal limiting membrane are : they show no striation ; they are less brilliant and substantial than the normal surface reflexes ; they occur under conditions of age, &c., when the normal reflexes from the internal limiting membrane are unlikely to be present ; and they may be seen to pass over both macula and disc.

(2) *The linear reflexes.*—(*a*) *From the internal limiting membrane.* Among the physiological reflexes I referred to the reflex of Weiss, which takes the form of a more or less regular line parallel to the nasal border of the optic papilla apparently due to the presence of an elevated ridge formed by the converging nerve fibres in that situation. This may be looked upon as an incomplete annular reflex.

Annular reflexes are not infrequently found under pathological conditions. They frequently occur as a pronounced Weiss reflex in papillœdema, irrespective of the age of

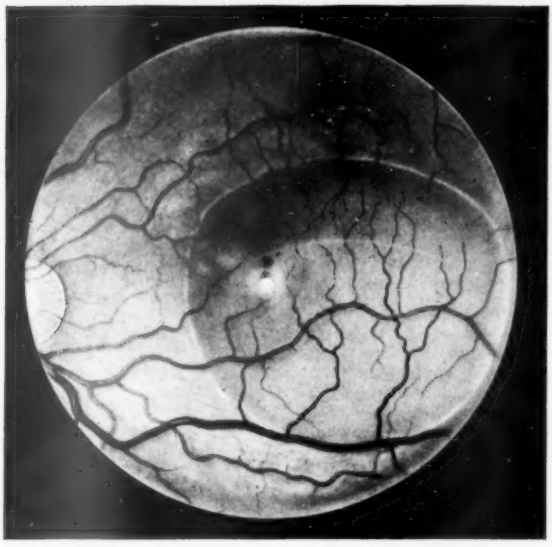

FIG. 11.—Central serous retinopathy showing annular reflexes.

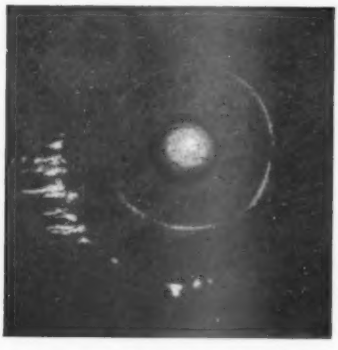

FIG. 12.—Chronic choroidal tubercle, with annular reflex.

FIG. 13.—Annular reflexes surrounding areas of choroidoretinal degeneration.

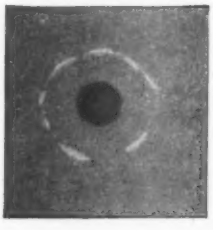

FIG. 14.—Annular reflex surrounding "black spot" at macula.

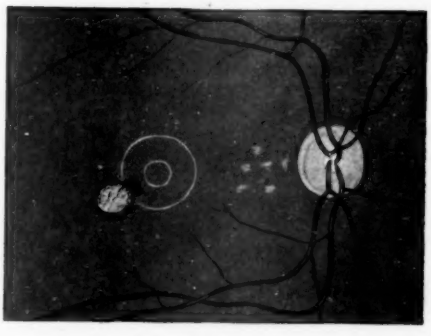

FIG. 15.—Double annular reflex in association with choroidal cicatrix and hæmorrhage.

the patient and the state of the refraction, but they may be found in any part of the fundus, at least within the central area, and usually indicate the presence of a more or less prominent dome-shaped elevation of the internal limiting membrane, with or without a corresponding elevation of the retina. Less frequently an annular reflex indicates the margin of a depressed area.

Such a reflex naturally springs to the eye in the course of ophthalmoscopic examination, and may direct attention to the presence of a lesion, such as a transparent colourless exudate, which might otherwise escape notice. Thus, in a case of subacute anterior uveitis, of tubercular origin, in which, in spite of increasing transparency of the media there was persistently low visual acuity, the recognition of a central retinitis was definitely aided by the discovery of a reflex of this kind. The annular reflex disappeared as the uveal disturbance cleared up and vision improved.

An excellent example of the annular reflex is provided by fig. 11, kindly lent to me by Professor A. Löwenstein, from a case of central serous retinopathy, and other illustrations occur from time to time in cases of massive retinal or subhyaloid hæmorrhage, choroidal tumour or tubercle (fig. 12), macular pseudo-tumour and other similar conditions.

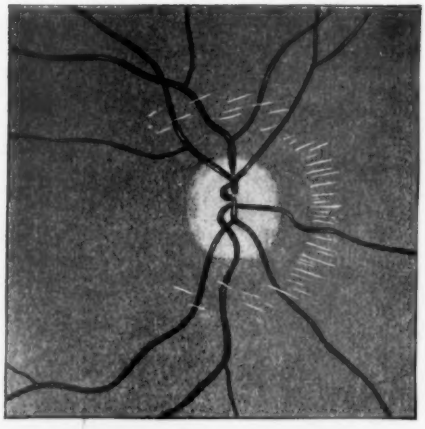

FIG. 16.—Needle reflexes surrounding the disc in retrobulbar neuritis.

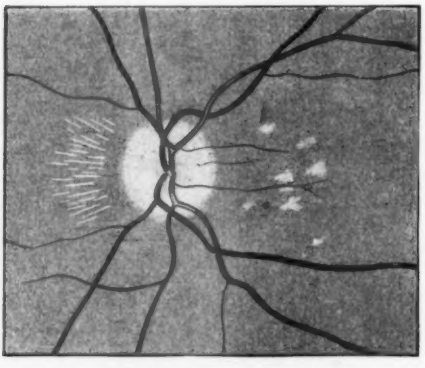

FIG. 17.—Needle reflexes nasal to disc in case of cerebral concussion. (L.)

An annular reflex, sometimes of fairly regular shape, may form part of the picture in cases of macular disease, such as familial macular dystrophy, or surrounding a focus of choroidoretinal degeneration (fig. 13). The reflex is apparently formed on the margin of the abnormal area, and it gives one the impression that it encloses a shallow depression.

Annular surface reflexes on a smaller scale are often seen as more or less broken rings surrounding clumps of pigment, as in fig. 14, from the macula of a myopic eye, or rounded patches of exudate in various forms of choroidal disease. An unusual example is seen in fig. 15, where a double annular reflex is seen, not surrounding, but adjacent to, a choroidoretinal cicatrix with a hæmorrhage.

In referring to the *needle reflexes* I doubted whether they ever occur in normal conditions (see case referred to under "physiological reflexes"). Certainly they have been seen in their most typical and pronounced form in pathological cases, as, for example, in cases of retrobulbar neuritis and papillœdema (fig. 16). They were also present on the nasal side of the disc in a case of penetrating wound

of the sclera on the nasal side. They were seen in very typical form in both fundi of a young man suffering from cerebral concussion, with a moderate degree of papillœdema (fig. 17). The reflexes were at the nasal side of the disc, discrete, straight, narrow, brilliant streaks which, beginning about one p.d. from the disc shot out into the fundus to a distance of three p.d.s following the movements of the ophthalmoscopic mirror radially to the disc. As the papillœdema subsided, the striate reflexes tended to coalesce to form small, striated, patches, and about four weeks after their onset the needle-like character of the reflexes had disappeared. Another example may be given from a case of double papillœdema in a female patient 28 years of age. Needle reflexes are occasionally seen in the neighbourhood of patches of massive exudate (no illustration).

These reflexes probably indicate a fine radial folding of the membrana limitans interna. They are very straight in direction and much finer than the double contoured lines described by Vogt, and the lines due to retinal traction and to external ocular pressure to which I shall refer later.

Vogt, in 1917, described in some detail a form of preretinal reflex which might be referred to as a linear reflex of pathological significance. It had been described many years before by Siegrist who was probably correct in supposing that it is formed on the same plane as the mobile surface reflexes, namely, the internal limiting membrane of the

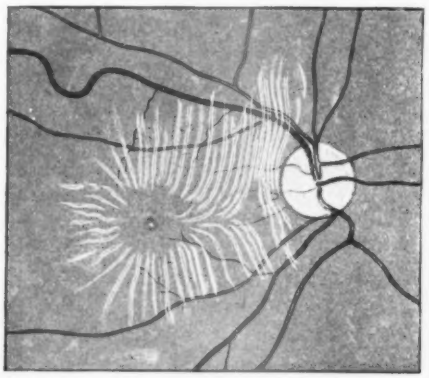

FIG. 18.—Linear reflexes with double contour. After Vogt.

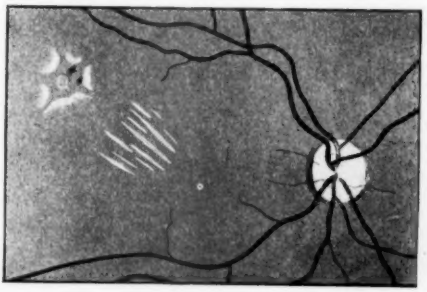

FIG. 19.—Double contour linear reflexes between macula and a choroidoretinal cicatrix.

retina. These reflexes are found in association with such disease conditions as retrobulbar neuritis, iridocyclitis, and the œdema resulting from contusio bulbi. The diagram (fig. 18), based on Vogt's illustrations, shows one characteristic form of the lines. They take the form of parallel pairs of bright lines enclosing a dark interval about the width of a primary or secondary retinal artery. Sometimes the bright lines join each other so as to form long spindles, sometimes they bifurcate. They have the elusive quality of the other surface reflexes, so that they do not form a stable pattern but come and go with the movements of the light. Vogt made a study of the physical and optical factors governing the appearance of these double-contoured reflexes, and reproduced them in the form of folds of Descemet's membrane in excised corneæ. They can sometimes be seen in characteristic form in the wrinkled lens capsule after cataract extraction, and an excellent "model" can be made by wrinkling a thin sheet of cellophane.

In the retina Vogt found the lines for the most part limited to the central area, and my own observations confirm this, but fig. 19 illustrates a case in which a group of similar lines was seen in the temporal half of the fundus some distance beyond the macula. There is a small patch of old retinitis some distance up and out from the macula; between the patch and the macula lies a group of brilliant, double-contoured

reflex lines similar to those described by Vogt, but their association with the retinal scar, and their direction between it and the macula, convey the definite suggestion of traction folds.

I think we are bound to believe that all the linear reflexes, whatever their form, represent lines of tension in the reflecting surface, which, in the case of the mobile, glistening reflexes, is the surface of the membrana limitans interna.

It is a familiar fact seen in post-mortem specimens, and illustrated in fig. 1, that a ridge of retina tends to form between the disc and the macula. Under many pathological conditions the ophthalmoscope shows us linear surface reflexes, sometimes singly and sometimes doubly contoured, in this same situation. Fig. 20 shows this diagrammatically in a case of simple glaucoma, some of the reflexes having the double contour, and somewhat similar lines are seen in fig. 21. They are associated with a choroidal cicatrix at the nasal side of the disc but seem to be rather a sign of some active disease with retinal œdema.

Reflexes of the double contour type are not at all uncommon around the macula in cases where one might expect to find a watery œdema or a slightly turbid infiltration of that region (macular hole, cystic degeneration, œdema under the internal limiting membrane, central senile exudative retinitis, &c.) and even in other parts of the fundus. They do not always form the typical pattern shown in Vogt's illustration, and they are

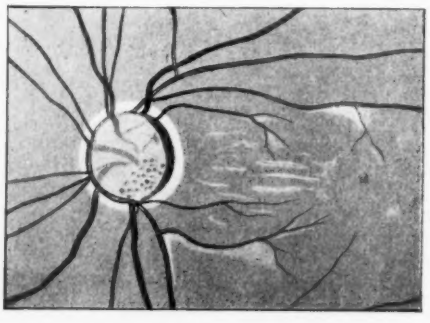

FIG. 20.—Papillo-macular linear reflexes in case of simple glaucoma.

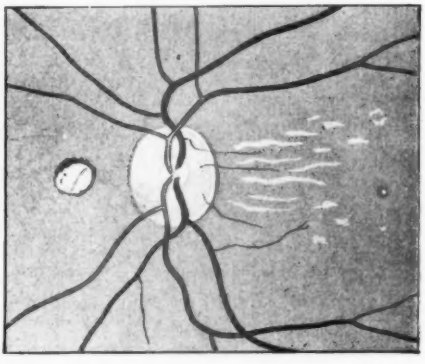

FIG. 21.—Linear reflexes in papillo-macular area. Choroidal scar nasal to the disc.

seldom visible over such an extensive area. Moreover it will be noticed that in Vogt's description and figures the lines take a sinuous course, and this is usual where they occur in cases of contusio bulbi, anterior uveitis, and other conditions characterized by œdema in the central area ; but in other cases, such as the one I have just referred to (fig. 19) the lines run straight between two fixed points, such as the disc and macula, or a scar and the macula. Thus, straight linear reflexes with double contour seem to indicate lines of tension in the retina, between two more or less fixed points, and therefore belong to the category of traction folds.

It is interesting to note that while the double contour is sometimes a striking feature, we just as often see bright linear reflexes in the same situations, and in similar pathological conditions, which differ from Vogt's reflexes only in being single lines. Sometimes single and double lines are seen in the same picture, and they may change from single to double or vice versa, with movements of the ophthalmoscopic light. This phenomenon can be reproduced on a model of cellophane or other glassy material presenting a series of parallel ridges and furrows. Thus, the three photographs in fig. 22 were taken from one and the same sheet of corrugated glazed paper, and they show that by altering the incidence of the light and angle of observation, one can produce several

different appearances, corresponding to some of those observed in the fundus: the ridge and furrow may act as alternating convex and concave cylindrical mirrors which give a succession of narrow brilliant lines on a darker background (*a*), or, the reflexes from the convex and concave surfaces may be caused to approach each other so as to form pairs of reflex lines resembling the double contour reflexes (*b*), or, by a further change of angle the paired lines may approach each other and fuse to form broader reflex lines separated by dark intervals (*c*). It would seem that the double contoured reflexes do not differ in their significance from the single contoured linear reflexes of similar distribution; and not only are these two forms interchangeable, but we meet with transitions from straight narrow needle reflexes to broader single or double contoured sinuous lines in adjacent parts of the same fundus.

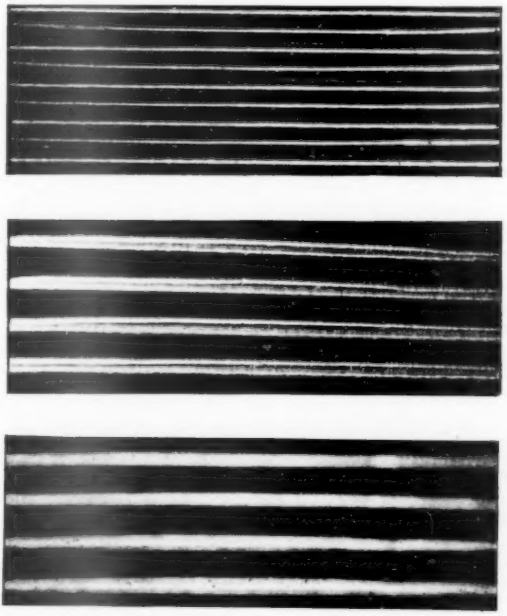

FIG. 22.—Linear reflexes from a glazed corrugated surface, with varying incidence of light.

The width of the reflex lines, and their form (whether straight or sinuous) will naturally depend chiefly on the form of the corrugations of the reflecting surface.

(*b*) *Intraretinal lines.*—When there is a scar in the retina, whether from injury or from disease, one often finds pale reflex lines, known as *Traction folds,* running between the scar and the disc or the macula. They may have the glistening quality of the preretinal reflexes, indicating that the internal limiting membrane is involved in the folding, or they have the matt appearance of purely intraretinal folds. Reflexes of these two kinds can exist together or separately. In the former case, the pattern of the one is a more or less exact replica of the other. Examination with the sodium lamp will eliminate the preretinal reflexes and enable us to determine whether intraretinal folds are or are not present.

An unusual form of traction folds, a linear arrangement of punctate reflexes, is seen in fig. 23. The cause of the folds is a choroidoretinal scar in the upper temporal part of

the fundus, and apparently this cicatrix, the macula and the disc, form three fixed points which determine the lines of tension.

In many cases of choroidal tumour, macular pseudo-tumour and similar lesions, one sees long delicate lines running radially from the surface of the prominence into the surrounding retina. These also appear to be traction folds, although their mechanism is different from that of the folds already mentioned. As a rule they do not have the

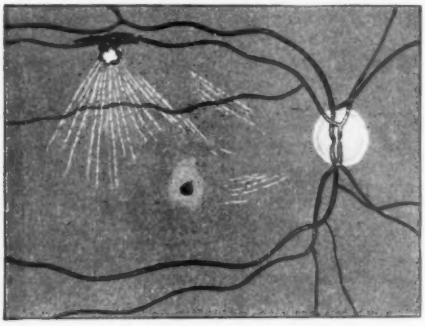

FIG. 23.—Punctate reflexes in linear arrangement—traction folds.

FIG. 24.—Traction folds surrounding massive hæmorrhage.

glistening quality of the needle reflexes; they are not closely set, the intervals between them being several times the width of the lines themselves. They are perfectly straight and sometimes each narrow pale line is shaded on one side or on both. The absence of a bright surface reflex causes one to infer that there is here a folding of the retina proper without deformation of the internal limiting membrane (fig. 24).

Somewhat similar, but broader lines, often with unilateral shading are the pressure folds, seen in cases where the eyeball is compressed by tumour, cyst or abscess in the orbit. These lines are usually seen outside the central area, for example, on the nasal side of the fundus when the pressure is exerted by a tumour or abscess extending from the ethmoidal cells, or in the upper temporal region when pressure is due to the presence of a lachrymal gland or other tumour in the upper-outer part of the orbit. Perhaps the presence or absence of such folds is influenced by the rate of growth of the causative lesion. There is reason to believe that when growth is slow and exophthalmos develops, there is less liability to the formation of retinal pressure folds. Pressure folds do not usually show the glistening appearance or sinuous course of the linear surface reflexes. They are usually matt in character and take the form of pale bands, as wide as a retinal artery, or even wider, running parallel to each other, and in a curve centred on the presumed point of maximum pressure. Hence their concavity is usually towards the periphery of the fundus. Sometimes, with movements of the ophthalmoscope mirror they show a variable incidence of light and shade suggesting a series of parallel ridges and furrows. This can be particularly well brought out if we use the ophthalmoscope lamp with a single straight filament, and focus this close to the fold. If we shift the image of the filament from one side of the fold to the other, a reversal of the shadow is obtained.

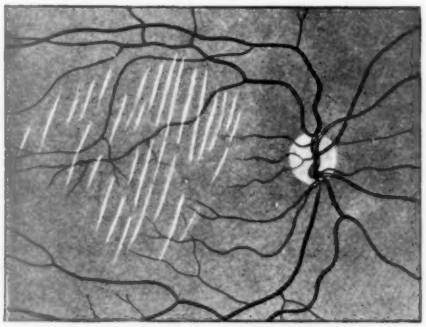

FIG. 25.—Pressure folds with double contour reflexes. Neoplasm in region of lachrymal gland.

The occurrence of true retinal folds without corresponding ripples or corrugations of the anterior surface of the retina, that is to say, of the internal limiting membrane, is not easy to explain. It may be that indentation of the sclera crowds and distorts the deeper layers of the retina while putting the anterior layer on the stretch, so that the internal limiting membrane does not participate in the wrinkling effect. The presence of broken lines of pigment in association with the pressure folds is evidence of a disturbance of the deeper retinal layers.

Although pressure folds are not usually accompanied by linear surface reflexes, the latter *may* be present, as in the case illustrated in fig. 25, of a man, 32 years of age, with a fibrosarcoma in the upper-outer part of his right orbit, whose fundus presented a series of glistening linear reflexes running obliquely in the 1—7 o'clock direction in the outer-central area. Even with the sodium light they had a double contour and tapering form, but doubtless they were pressure folds, accompanied by rippling of the internal limiting membrane. It is interesting to note that in some cases, when pressure has been relieved by removal of the tumour or cyst, the pressure folds disappear, while in others they are permanent. The principal factor here may be the length of time that elapses before the pressure is relieved. If there is a long interval there would probably be time for the retinal folds to adhere and become fixed in their abnormal form.

Sometimes in cases of papillœdema (usually in the stage of subsidence) one sees, adjacent to the disc and most commonly on the temporal side, a series of very narrow lines, parallel to each other and concentric with the disc margin. These apparently represent corrugations of the retina due to the swelling and lateral expansion of the papilla. Here, again, there are no corresponding surface reflexes to suggest rippling of the internal limiting membrane, but the lines present an alternation of light and shade, like the pressure folds on a smaller scale. They are somewhat broader and more clearly marked than the nerve-fibre bundles in the same situation, which often interlace with them to form a criss-cross pattern. Similar corrugations are occasionally seen bordering a retinal elevation due to tumour or hæmorrhage.

In one case of acute ethmoiditis delicate folds of this type were seen running vertically at the *nasal* side of the disc. As there was some œdema of the disc margin it was uncertain whether the corrugations were the result of the papillœdema or were to be regarded as pressure folds due to the extra-ocular pressure.

In a case of subsiding papillœdema one saw the very unusual appearance of a group of such ripples or corrugations up and in from the fovea. They were concentric with the macula and the ones nearest to the fovea were short, the most distal ones the largest, so that they formed a fan-shaped patch. At a later date this group of ripples had disappeared.

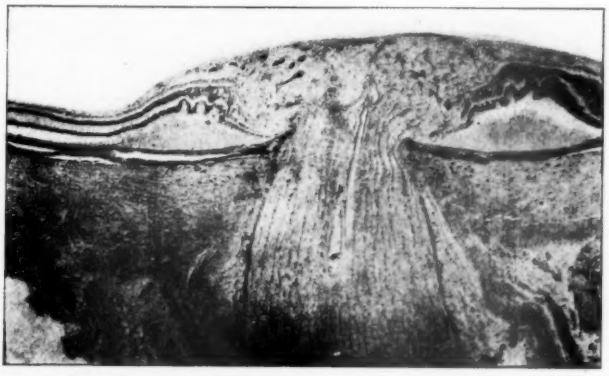

FIG. 26.—Papillœdema. Folding of deep retinal layers without involvement of the surface layers. × 13.

In all such cases one appears to be dealing with narrow intraretinal folds, not accompanied by folding of the internal limiting membrane. We have no direct proof of this; but we are familiar with the histological picture of papillœdema, in which there is a rucking up of the nuclear layers of the retina near the disc while the surface of the disc and adjacent retina preserves a smooth contour (fig. 26). In the course of slit-lamp examination of the fundus, Kath. Bangerter-Blaser (1939) has made the observation in two cases of papillœdema, that such ripples adjacent to the papilla involved only the retina proper and not the internal limiting membrane.

The nature and significance of these linear reflexes, as indeed of all the retinal reflexes, will be made clearer by studying them under different forms of illumination. Vogt described his double contour reflexes among the phenomena revealed by red-free light. They are often quite easily seen with the ordinary light of the electric ophthalmoscope, but all the surface reflexes are more obvious in short-wave illumination. This is not always an advantage. If we use such a powerful source as the arc lamp or the mercury vapour lamp, all the surface reflexes, physiological and pathological, are emphasized, and often form a confusing picture. Moreover, it is not possible by such light alone to determine the relationship of the reflexes to the deeper elements in the retina and choroid.

The investigation of the fundus reflexes is not complete until they have been examined also with a long wave light such as that of the sodium vapour lamp. One of the interesting results of ophthalmoscopy with the sodium vapour lamp is the complete or almost complete elimination of all surface reflexes. This often reveals the presence of fine lesions of the retina or choroid which are invisible in polychromatic light, partly because they are concealed or confused by the presence of the surface reflexes. In the case of the linear reflexes, the sodium light reveals what lies behind and brings out the interesting fact that the condition of the underlying parts is not always the same. Sometimes after removal of the surface reflexes we can discover no abnormality of the retinal contour ; in other cases we see a system of lines corresponding in pattern to that of the surface reflexes, but more deeply situated, stable, and of matt appearance, while in still other cases (e.g. pressure folds), we see such deep, matt lines which, even with short-wave light, show no corresponding surface reflex. It would thus seem to be proved that ripples or folds may sometimes involve the retina plus the internal limiting membrane, sometimes the membrane alone, and sometimes the retina alone. Vogt's observations were chiefly concerned with the effects of red-free light, and he emphasized the difference between the preretinal folds (in the internal limiting membrane) and the true retinal folds, referred to above as intraretinal. Ophthalmoscopy with the sodium light takes us further by proving that each of these may occur independently, or in combination with the other.

It should be noticed here that the Cardell-Keeler polarized ophthalmoscope also has the property of eliminating the surface reflexes, which may enhance its usefulness in ophthalmoscopic diagnosis. It has the advantage over the sodium vapour lamp that it preserves the normal colour values of the fundus picture, but it does not reveal, as does the sodium lamp, the details of choroidal and deep retinal lesions, or of the retinal blood-vessels.

Except perhaps in the case of the juxtapapillary corrugations seen in papillœdema, the histological explanation of the linear reflexes has not been, and is scarcely likely to be, demonstrated. But it is safe to assume that they all represent lines of tension in the retina, the internal limiting membrane or both together. The more sinuous reflexes situated in the papillo-macular or peri-macular areas, which often reveal no corresponding deeply situated lines when examined with the sodium light, are possibly due to distortion of the internal limiting membrane by fluid between it and the retina, while the so-called traction and pressure folds probably involve the retina proper with or without the internal limiting membrane. Retinal folds *without* preretinal reflexes are usually due to non-inflammatory conditions—pressure by extra-ocular tumours, traction from retino-choroidal scarring. On the other hand, the presence of the preretinal reflexes usually indicates the existence of an inflammatory condition, or of œdema from some other cause, such as trauma.

(3) *Punctate reflexes.*—Although Gunn's dots are by no means universally present, indeed are unrecognized in the majority of eyes, they occur in perfectly normal eyes in normal subjects, and have shown no relation to any pathological state. We must therefore look upon them as physiological.

Brilliantly reflecting specks are seen occasionally, either singly or in small numbers, in hypertensive disease. The crystalline appearance of these specks suggests that they may consist of cholesterin, but Gifford and Cushman (1940), in reference to hyaline bodies at the macula, say that the shining crystals found in some cases are due to deposits of calcium carbonate in these bodies. Similar glistening or iridescent specks sometimes form in pre-existing drusen in the lamina vitrea of the choroid, or among the confluent white exudates of diabetic and other forms of retinitis. In the sodium light all these specks remain visible but lose their lustrous quality.

Grouped punctate reflexes often appear in and around the macula in cases of nephrosclerosis or essential hypertension. These are seldom well-defined specks or points, but rather like surface reflexes broken up into small fragments through minute irregularities of the surface. The only difference between these and the reflexes I have described as "fragmented" is one of size. Here again the sodium light helps us to interpret the picture, for in some cases it washes out the surface reflexes without revealing any underlying opacities, presumably because the surface irregularities are due to a transparent fluid or exudate, while in others it exposes minute punctate exudates which may be assuming a radiate arrangement, the earliest form of the macular star. Incidentally,

although drusen of the lamina vitrea cannot be counted among the reflexes, they are very common in and around the macula, and are always most easily seen with the help of the sodium lamp.

We have seen that in pathological cases several varieties of reflex—annular, linear, punctate, &c.—may coexist in the same fundus. It is characteristic of the pathological reflexes in general that they are not so static as the physiological reflexes. They tend to disappear or to undergo changes of type corresponding with the character or phase of the local disorder. In one case of choked disc of unknown origin, the first observation showed needle reflexes at the nasal side of the discs. Later, at the time when the papillœdema was at its height, and was accompanied by some hæmorrhage and exudates, the reflexes took the form of fine needles radiating from the disc area in all directions, not only nasally but also on the temporal side as far as the macula or beyond it. When the papillœdema was undergoing a gradual recovery, with improving vision, the needle reflexes between the disc and macula assumed the form of the broader double contour reflex lines of Vogt, while the needle reflexes nasal to the disc became shorter and more closely packed, until they formed a "Weiss" reflex with radial striation. In the better eye the reflexes in the papillo-macular area became fragmented and lost their linear form. In the worse eye there was at this stage a group of fine parallel corrugations up and in from the macula (referred to in describing the linear reflexes). In six weeks these had disappeared and the fovea was now surrounded by two or three patches of silvery surface reflex within the border of the macula. In the course of the five months in which these changes were taking place, the vision improved from R. $= \frac{6}{12}$: L. $= \frac{6}{24}$ to R. and L. $\frac{6}{6}$.

A boy 12 years of age complained of dimness of vision of sudden onset in one eye. The V.A. of the eye was $\frac{6}{24}$ and the ophthalmoscope showed Vogt reflexes radiating from the macular region. Two days later these reflexes had given place to a group of normal patchy surface reflexes and the vision had risen to $\frac{6}{9}$, subsequently improving to $\frac{6}{5}$. The pathological condition seemed to be a transient macular œdema.

It will be evident that the observation of such changes in the reflexes may aid us in estimating the progress of the case towards recovery or otherwise.

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Proceedings of the Royal Society of Medicine Vol. XXXIV 43

JOINT DISCUSSION No. 1

Sections of Surgery and Therapeutics & Pharmacology

Chairman—J. B. HUNTER, M.C., M.Ch.
(President of the Section of Surgery,
supported by Sir William Willcox, President of the Section of Therapeutics and Pharmacology)

[*November* 6, 1940]

DISCUSSION ON THE TREATMENT OF BURNS

Surgeon Rear-Admiral Cecil P. G. Wakeley : At the outbreak of hostilities the treatment of burns by tannic acid was considered completely satisfactory. Experience, however, disproved this and in the Royal Navy where burn casualties have been numerous, many other methods have been tried and the cases carefully followed up.

War burns differ considerably from those seen in civilian life, for they may not be treated in hospital for hours or even days after the receipt of the injury, whilst in the case of the civilian, hospital treatment is forthcoming, as a rule, within an hour.

Under war conditions in a battleship, tank or aircraft in action, first-aid treatment of burns is all that can be given in the vast majority of cases, but as soon as possible they are transferred to hospital ships or hospitals, where full treatment can be carried out.

The greater number of war burns involve the face and hands, and are caused by gun-flash, bomb-flash, incendiary bombs and petrol, while a smaller number are due to chemicals or electricity in the shape of broken cables and short circuits. The first-aid treatment consists in morphia to relieve pain, warmth, and fluid by mouth to counteract shock. If shock is very marked plasma transfusion is given. Morphia should be given in doses of ⅓ gr. and repeated if necessary. *Morphia will never kill a man who is in pain.* On many occasions I have seen badly burnt men arrive in hospital after a sea journey lasting over twelve hours, in excellent condition, and on looking at their tickets I have been pleased to see that they have had injections of morphia amounting to 1 gr.

Most war burns consist of a mixture of first, second, and third degree, while some are wholly third degree. War burns may be considered as those which involve partial skin loss (first and second degree) and those which involve total skin loss (third degree), and it is essential that medical officers should try to differentiate between these two degrees. As a general working rule it may be said that if examination of the burnt area reveals any sign of dermal circulation the burn has not passed beyond the second degree ; whereas in third degree burns there is no circulation and the burnt area remains dull and of a yellowish-white colour.

In the treatment of war burns three essential factors require consideration, namely: (1) Shock, (2) Toxæmia, (3) Sepsis.

(1) SHOCK.—This may be divided into primary and secondary.

Primary shock is the result of the burn and is directly responsible for very few deaths. It is characterized by a fall in blood-pressure, feeble pulse and cold clammy skin. The temperature is subnormal. The severity of the primary shock depends mostly on the extent of the burn rather than on its depth ; any case where more than 25% of the body surface is involved may prove fatal. Notwithstanding this, several cases have been treated in naval hospitals during the last year in which much bigger areas were involved and a successful issue has been obtained.

The treatment of primary shock should be prompt : a hypodermic injection of morphia ⅓ gr., repeated in an hour if the pain is not relieved. Warm blankets and hot sweetened drinks will quickly restore the patient.

Secondary shock is a much more serious condition and occurs as a collapse some few hours after the receipt of the burn. It is most serious and accounts for quite 80% of the total deaths in burn cases. Burns of the thorax, abdomen and face appear to cause more shock or collapse than those occurring on the extremities.

There may be a definite interval between recovery from the initial shock and the development of secondary collapse, or the initial condition may simply merge into one of secondary shock. The patient complains of thirst and this is often accentuated by vomiting. The blood-pressure falls, the pulse is feeble, the respirations are rapid and shallow, and the temperature is subnormal.

The most important factor probably in the causation of secondary shock is the great loss of plasma from the burnt surfaces and into the tissue spaces. Although some fluid with its valuable protein is actually lost externally the amount is quite small compared with that which accumulates in the tissues. It is in reality a fluid imbalance ; there is a shift of fluid rather than an external loss. The blood becomes concentrated and the hæmoglobin may rise to anything between 105 and 140%. It is important to realize this as the fluid lost from the blood-vessels to the tissues can best be regained by replacing the lost plasma protein. If plasma is given intravenously it raises the plasma osmotic pressure to a value sufficient to restore and maintain the normal distribution of fluid between the intravascular and interstitial compartments. Whole blood transfusion is contra-indicated as it increases the corpuscular concentration and the capillaries become blocked with a huge excess of red blood corpuscles. Intravenous normal saline or sterile water are also contra-indicated because the former increases the œdema while the latter may result in a hazardous lowering of the extracellular electrolyte concentration producing water intoxication.

The amount of plasma necessary must be estimated by frequent blood examinations and the corpuscular concentration gradually relieved. Pain is controlled by morphia and the absorption of toxins prevented by some application which will coagulate the burnt tissues.

(2) Toxæmia.—The cause of acute toxæmia occurring in burns is still in doubt but an investigation into several hundred cases of war burns seems to support the view put forward by Aldrich that it is due to infection by streptococci. The toxæmia does not appear for several days after the infliction of the burn and can be prevented by adequate primary cleansing before coagulation is undertaken. In the war of 1914-1918 nearly three thousand cases of burns were treated in the Royal Naval Hospitals and Hospital Ships, and acute toxæmia was a constant feature. In the present struggle, it has not been nearly so frequent and there can be no doubt that the coagulation therapy is responsible for this marked decrease.

The clinical symptoms of toxæmia may vary with the severity of the condition but there is generally restlessness and delirium. The pulse is rapid and vomiting is a very constant symptom. Circulatory failure with a fall in blood-pressure may cause a fatal issue. Albuminuria is always present when the toxæmia is marked.

For extensive burns with toxæmia, saline baths have proved most valuable.

(3) Sepsis.—This has proved a real problem in war burns and its prevention has not been so easy as was expected. In first and second degree burns septic infection can be prevented provided local coagulation treatment is given immediately after the injury and this treatment is followed by adequate cleansing and coagulation when the patient reaches hospital. However, this is not always possible under war conditions, especially at sea, and sepsis may be well marked by the time the patient reaches hospital. It is the third degree burns which form the major problem, for fully 90% of these become infected, the commonest organism being the hæmolytic streptococcus. The contamination probably comes from the patient's own skin. When sepsis is present any tan should be removed and saline baths instituted.

Treatment

Local treatment falls into two definite categories: i.e. first-aid treatment and hospital treatment ; very few war burns can be treated in hospital soon after the receipt of the injury.

First-aid treatment.—This must be simple, painless and quick in application as many

cases may have to be treated in a short time. A jelly preparation is without doubt the best application, as there is not time to use a spray or any other form of elaborate technique, and space is often limited on board a battleship during action ; nor do the inside of a tank or aircraft allow of much in the way of extra room for surgical cleansing. There are many jelly preparations made at present and having tried them all I am in favour of gentian violet jelly with merthiolate (1 : 5,000). The jelly is contained in a tube, which in itself is important, for dressings and solutions are often damaged by sea water and broken water pipes during naval actions, whereas tubes are not spoilt in the least by water, oil, grease and many other things that float about a sick bay or dressing station during or after an action.

FIG. 1.

Gentian violet jelly can be applied to the burnt area without any cleansing whatsoever. The application should be liberal for it is painless and even soothing. The jelly will seal off the burnt area and a crust forms which remains in place until the patient arrives in hospital.

There are other preparations which give good result, but none of them has such a penetrating and antiseptic action.

The local treatment of burns should not be given in the presence of shock which must be treated prior to any applications. No tannic acid preparation should be used on the hands or face ; in the case of the fingers the unyielding tannic acid coagulum encasing the digits causes an œdema which seriously interferes with the circulation and terminal necrosis of the phalanges may take place (figs. 1 and 2).

Hospital treatment.—In those cases which can be admitted to hospital immediately following a burn injury the treatment of shock is instituted and this is probably better planned to-day than ever before. Plasma banks and dried plasma have played and are playing a very important part in the treatment of shock due to burns. The employment of oxygen administration by the B.L.B. mask has also helped to reduce the incidence of death from shock. By means of the B.L.B. mask the oxygen tension may be raised to 80% and this in itself helps to reduce the incidence of fat embolism which is quite a constant finding in cases of fatal burns (44%).

FIG. 2.

After the shock has been treated the patient is taken to a warm theatre and anæsthetized with gas and oxygen. The whole burnt area is thoroughly cleansed, the surgical technique being as rigid as for an abdominal operation. Saline is the only solution used, all blistered and dead epidermis is excised and the whole area cleansed with saline. The area is then dried with an electric hair drier and an aqueous solution of triple dye

2% gentian violet
1% brilliant green
0·1% neutral acriflavine

is sprayed on the surface. This is then dried and a second application applied, which in turn is dried. Usually two applications are sufficient to produce a nice thin supple tan, which is quite adherent everywhere and no sepsis appears around the edges of the tan.

In those cases in which sepsis is evident owing to inefficient cleansing and insufficient tanning, an anæsthetic should be given and the area re-tanned. It is not always necessary to remove the pre-existing tan.

As a rule the tan becomes loosened about the eighth or ninth day, and gradually falls off bit by bit leaving a healed area underneath. If, however, the burn be an extensive one and mostly or entirely third degree, then the area should be excised and skin grafted. The same applies to electric burns.

The majority of war burns are admitted to hospital from several hours to several days after the injury and have had first-aid treatment only. In such cases a very thorough examination is made of the burnt area, and if there is any evidence of sepsis an anæsthetic

FIG. 3. Phosphorus burn of hand.

is administered and the tan removed. The underlying surface is cleansed with saline and tanned with triple dye.

The question as to whether or not to use sulphanilamide when sepsis is present is one which is often asked.

I consider that it is very rarely necessary to administer this drug because in third degree burns in which sepsis is a frequent complication, the skin is destroyed and with it a considerable amount of the body's supply of sulphur. It must be remembered that fully two-thirds of the body sulphur is in the skin and this sulphur must be replaced. The best method of sulphur replacement is by a liberal diet of eggs and these cannot be taken during sulphanilamide treatment. Moreover, many cases vomit while taking sulphanilamide and so further reduce their fluid and solid intake when it is important that

additional proteins should be given in a liberal diet. Also a high salt diet is necessary when a large granulating area is under treatment prior to skin grafting because of the loss of chlorides.

A certain proportion of war burns are complicated by open wounds or fractures; in such cases the hospital treatment for the burnt area is the same and the wound or fracture treated by immobilization in plaster of Paris.

With regard to the treatment of third degree burns early skin grafting is essential if good results are to be obtained and scarring, contractures, and disappointments prevented.

Late after-treatment.—After the healing of a burn it is very essential that the healed surface which is covered with new skin should be treated by the application of lanoline each day for fully six weeks. The lanoline should be rubbed into the area and this massage will result in a skin which is more supple and better supplied with blood. After skin grafting this treatment should also be adopted. In the past late after-treatment has been badly neglected and so the ultimate results have not been good.

FIG. 4. Keloid scarring of hands due to second and third degree burns. This could have been prevented by early skin grafting.

TYPES OF BURNS

Chemical burns.—So far chemical burns have not been much in evidence but one or two cases of phosphorus burns have been seen (fig. 3, *see* p. 47).

Phosphorus burns result from the back-flash of incendiary bombs containing phosphorus; some of these burns are extensive while others are small and due to the presence of a fragment of shell containing this substance. Such small burns are liable to become deeper as the phosphorus continues its thermal action on the tissues. As a first-aid treatment a solution of 2% copper sulphate should be applied, this combines with the phosphorus producing an inert chemical compound and so prevents any further action. It is important not to use oily dressings owing to the fact that phosphorus is readily soluble in oil. After one application of the copper sulphate solution the burnt area should be dried and then treated with triple dye.

Electrical burns.—These are by no means infrequent in the Navy and are due to broken electric cables and short circuits resulting from bombing attacks or gunfire. A certain proportion of these burns prove fatal and at times very little evidence can be produced as to the cause of death unless the medical officer is familiar with the tell-tale electric current mark. The shape of the mark varies with the shape of the object carrying the electricity, but usually they are circular or elliptical areas, varying in size from a pin's head to a pea. In colour they are greyish white, with a slightly raised periphery, a depressed centre, and no surrounding area of hyperæmia. They look glossy, feel smooth like parchment, and when on the fingers, result in the complete obliteration of the papillary lines over the area they occupy. Should the burnt area be more extensive the best form of treatment is complete excision followed by skin grafting. The small electric burn requires nothing more than the application of some triple dye.

Final assessment of war burns.—At this juncture the profession as a whole should have a more accurate mental picture of the end-results in the treatment of burns. It so often happens that the medical man who treats a burn and is satisfied with the immediate result, does not see the final effect in three months' time (fig. 4, p. 48) when keloid formation and contractures have taken place. A follow-up of burn cases is just as important as the follow-up of fractures.

Protection.—In war burns the great majority of cases involve the face and hands and in the Royal Navy this has been appreciated since the battle of Jutland in 1916. An anti-flash gear is now served out to every fighting ship for the use of ratings who are exposed to gun-flash or bomb-flash, and has resulted in a marked reduction in the number of burns.

Systemic Disturbances and Their Treatment in Extensive Burns

Professor W. C. Wilson: The systemic disturbances in burns are complex and obscure. The cause of some of them is still largely a matter of conjecture, and investigation on this subject is urgently required.

It is instructive to consider the systemic disturbances in relation to simultaneous pathological processes in the burnt area and to changes in the blood. Exposure of the skin to excessive heat kills instantly a large number of cells and injures many others. Attention has been directed mainly to the effects of injury on the blood-vessels, especially the capillaries and other minute vessels; much less is known of the effects on the tissue cells, on nerves, on lymphatics and on the blood circulating in the skin at the time of the injury. Yet it is not improbable that injury to any of these structures may have important consequences. For example, it is generally assumed that painful impulses from many injured nerve terminations are responsible for "initial shock" which sometimes appears very shortly after the burn is sustained. Experience, however, has shown that shock is rarely present within one hour of injury and that the common form of burn shock is the delayed or "secondary shock". Whether nerve impulses from the site of the burn play any part in initiating or perpetuating secondary shock is unknown. There is general agreement that injury to the smaller blood-vessels is the major factor in the causation of secondary shock. Fluid of a constitution closely approximating to plasma escapes through the walls of many vessels which have been rendered abnormally permeable by the injury. The abnormal permeability persists for periods of between thirty and forty hours but the passage of fluid from the blood-stream to tissue spaces seems to be most rapid during the first twelve hours and to become very slow after twenty-four hours. It has been established, however, that absorption does occur from burnt areas (Mason, Payton and Shoemaker, 1936). During this early period absorption is probably mainly by lymphatics and not directly into the blood-stream. The question of absorption requires further study.

The escape of plasma and its accumulation in the tissue spaces over a large extent of body surface is responsible for many changes. The total volume of circulating blood is reduced and the reduction is the main cause of the circulatory failure which is characteristic of secondary shock. In the blood there is the well-known change of hæmoconcentration (increased corpuscular concentration) which, in so far as it indicates plasma loss, is of serious significance. Whether hæmoconcentration *per se* impedes the circulation or interferes with oxygenation processes seems to me doubtful.

Various changes appear in blood chemistry shortly after the injury (Wilson and

Stewart, 1939), some of which are probably the result of changes in permeability of the cell-membranes or injured cells (Lowdon *et al.*, 1939), but it would seem that none of the changes are in themselves sufficient to account for circulatory failure during secondary shock. The decline of plasma protein concentration after burns was stressed by Weiner, Rowlette and Elman (1936) and has been confirmed by many others. In my experience loss of plasma protein is serious only when large quantities of saline or glucose are given intravenously. These non-protein fluids escape rapidly through injured capillary walls carrying protein with them and causing pronounced depletion of plasma protein.

It is by no means certain that plasma loss in the burnt area is the only cause of secondary shock. Shock is usually more profound in deep burns than in superficial burns of approximately the same extent and distribution, yet plasma exudation is probably greater in the latter, which implicate the skin only, than in the deeper burns, which destroy the whole depth of skin and penetrate to less vascular tissues. Another feature of burn shock on which little information is available is oliguria. This persists for twenty-four to forty-eight hours and seems to be unaffected by the introduction of even very large quantities of fluid.

Toxæmia

The next phase in the systemic disturbances is that of acute toxæmia which varies greatly in severity. The main features of a severe toxæmia are pyrexia, anxiety or stupor progressing to delirium and coma, vomiting, sometimes of blood, a tinge of jaundice, albuminuria and circulatory failure. The characteristic pathological change is necrosis and degeneration of the liver cells. The fulminating form of this condition is now distinctly uncommon but even in favourably progressing cases indications of mild toxæmia are often seen. In some of our patients who showed few or no signs of toxæmia, Thomson and Wilkinson found evidence of impaired liver function in lævulose tolerance tests. Similar results have been reported by McClure and Lam (1940), and by Wolff, Elkinton and Rhoads (1940).

The blood changes associated with toxæmia are neither constant nor pronounced. Reduction of plasma protein, especially albumin, may persist; chlorides, CO_2 combining power and serum sodium may be reduced and the icteric index raised by liver damage. Toxæmia, however, is not accompanied by hæmoconcentration. On the contrary the development of severe manifestations coincides with dilution of the blood and, presumably, with resorption of fluid, including that which had accumulated in the burnt area. Liver necrosis, which is sometimes so severe that it is incompatible with continued survival, is strong presumptive evidence of the action of a circulating toxin. Possible mechanisms of toxin production are bacterial infection and tissue autolysis at the site of the burn. The hypothesis of bacterial infection is attractive. Bacteria cannot be entirely excluded from a burn; like all wounds it is in some degree infected. Yet the hypothesis is not supported by available evidence. Bacterial growth in the burnt area may be surprisingly slight and it bears no close relation to the intensity of toxæmia. Moreover the characteristic liver lesion is probably never found after infections, even of the most virulent type, by the bacteria commonly present in burns. There are objections to the hypothesis of tissue autolysis and the most serious is that aseptic autolysis does not produce potent toxins. Possibly autolysis is effective in toxin production only if accelerated and augmented by bacterial action.

Sepsis

The cause of the next phase—sepsis—is not in doubt. Infection by the hæmolytic streptococcus is frequent in deep burns after the first week and recently I have noted the presence of *Staphylococcus aureus* in many infected areas. The grave danger is septicæmia and pyæmia.

If the principles of treatment are clearly appreciated, and if common sense is used, the details of treatment can be left to individual choice. In the early stages warmth, morphine, hot drinks and protection against the factors which aggravate shock are necessary. If the area involved is extensive the rule " no local treatment before resuscitation " should be rigidly applied. Resuscitation is carried out by transfusion of plasma in quantities adequate to restore the lost plasma. The plasma volume and circulatory efficiency are measured by repeated estimations of hæmoglobin and blood-pressure. During the first forty-eight hours further plasma transfusions may be required.

Fortunately, secondary shock of burns responds very readily to this treatment, as was our previous experience with gum acacia, and hæmoconcentration disappears. In the most severe shock a useful adjuvant measure is desoxycorticosterone acetate—a synthetic suprarenal cortical hormone—which, though by itself it has little effect on blood-pressure, corrects rapidly most of the blood changes and is definitely beneficial. Fig. 1 illustrates how quickly the blood changes, including hæmoconcentration, in experimental scalds are corrected by the hormone.

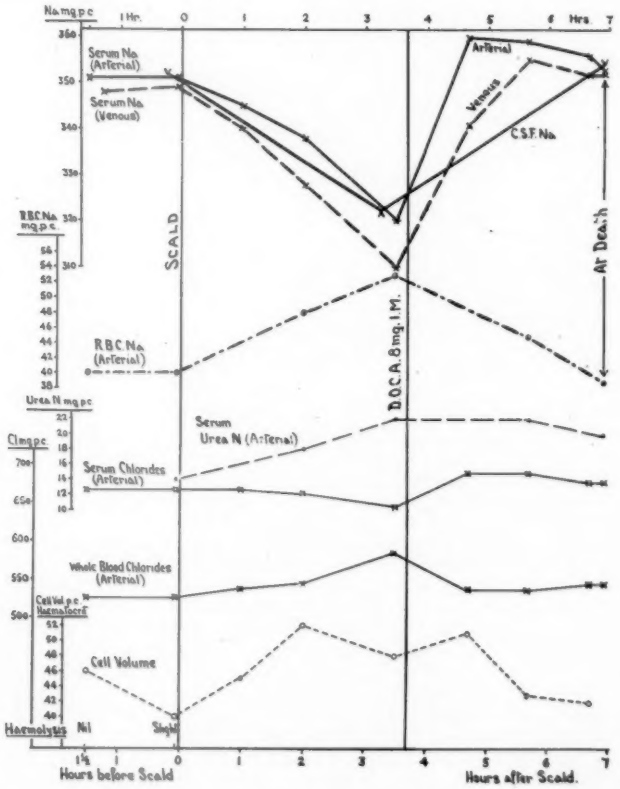

FIG. 1.—An experiment by Lowdon *et al.* (1939.) Dog. 10·4 kg. Nembutal 0·04 g/kg. Scald by water at 98° C. Note changes in blood chemistry, especially fall of serum sodium and of C.S.F. sodium and rise in corpuscular concentration. Desoxycorticosterone acetate (8 mgm.) given 3 hours 40 min. later. Note rapid reversal of blood changes.

At this early stage caution must be exercised in the intravenous administration of non-protein fluid. Dextrose saline may be given to protect the liver against the toxic factor and plasma protein estimations during the first few days are of value in guarding against protein depletion. Trusler *et al.* (1939) have suggested that water intoxication is a definite risk if large quantities of fluids are given by the alimentary tract. The danger is not serious if ordinary care is exercised, but the practice of "forcing" fluids in burns is pernicious. The circulatory failure of toxæmia may, if severe, be resistant to treatment

but sometimes benefit, or even a dramatic success, is achieved by synthetic cortical hormone or cortical extract.

In the stage of sepsis the important general measure is exhibition of sulphanilamide or sulphapyridine. It may have little effect on the local septic process but it protects against the dangers of septicæmia and pyæmia. Experience has shown that the course is favourably influenced by blood transfusion. We have found low levels of serum sodium at this stage. To preserve the normal level of sodium and to aid protein regeneration a high salt and high protein diet is recommended. On general principles it should be rich in vitamins.

Local Treatment

Experience has confirmed my opinion that the coagulation method is the most suitable for all but exceptional circumstances. It is directed at neutralizing the dangers of shock, toxæmia and sepsis. When properly conducted, it relieves pain, lessens surface exudation of fluid and plasma loss, minimizes tissue autolysis and produces conditions unsuitable for bacterial growth. Certain dangers exist if this method is used for burns of the hands and fingers but they are easily avoided. In deep burns the aim, as in the treatment of dry gangrene, is to keep the sloughs dry till they are separated by the growth of granulation tissue. Immediately after the sloughs and exudate are cleaned off the granulating surface can be prepared for skin grafting.

Many modifications of the coagulation method are available. I now use a single application of a 10% solution of silver nitrate, preceded and followed by applications of 1% crystal violet. For areas which cannot be constantly exposed to the air, or for any reason cannot easily be kept dry the following jelly preparation is useful:—

Tragacanth	2 parts
Glycerol	10 parts
Powdered charcoal (B.D.H. activated)	15 parts
Silver nitrate	0·5 part
Water to	100 parts

It is applied with or without a single layer of gauze mesh and it quickly forms a firm, but fairly pliable, dry occlusive covering. Silver nitrate is included as a slow coagulant and antiseptic, the charcoal with the object of adsorbing fluid, bacteria and their products. I prefer it to the tannic acid-acriflavine jelly recently recommended (Wilson, 1940).

An alternative to coagulation treatment is to soak off sloughs by saline packs or by repeated or continuous immersion in saline baths. This method produces a clean granulating surface more quickly than does the coagulation method and it is useful for deep burns of limited extent, particularly of the hands. It is, however, laborious and requires constant attention by specially trained personnel. Moreover, there is as yet no good evidence that it can be employed with safety for extensive injuries. Studies of the systemic disturbances under this treatment would be of great interest but few seem to have been made ; even post-mortem reports are not available.

Every effort should be made to obtain healing with a minimum of scarring and contracture, deformity and disability. But there is an unfortunate tendency, by no means uncommon in surgeons, to concentrate entirely on the local condition and to neglect general measures.

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Combination of Burns and Wounds

Wing Commander Cecil Flemming : I shall deal with one particular group of cases, namely, the type of case which one sees in the R.A.F. with a combination of burns and wounds. Unlike naval experience, one does have an opportunity of treating these patients in hospital at a very early stage. They usually occur as a result of crashes in which the aircraft catches fire. If the burns are more extensive the combined shock of the burn and of the crash may be fatal. But the problem which the practical surgeon has to face is what to do about the wounds. The ultimate cosmetic and functional recovery depends enormously on early surgical treatment, probably more so in the face than in any other part of the body except the hands. Therefore the first problem is how soon it is safe to give these patients an anæsthetic and what sort of anæsthetic to give them.

As to how soon it is safe to give an anæsthetic it is easy to say that it depends on the shock, but unless one can find some pathological criteria which will give some sort of clue as to the patient's condition one is rather in a state of confusion. I have tried using the estimation of the concentration of hæmoglobin, and there is almost invariably in burns some increase in such concentration. In a severe case of mine, despite the injection of serum, the hæmoglobin rose from 110 to 140% before the fall began, and during that period there was œdema and falling blood-pressure. But the hæmoglobin concentration, however accurate it may be as a guide, is, after all, likely to be affected if one is dealing at the same time with a patient who has been wounded and has been bleeding. The first question is the extent to which the hæmoglobin concentration is a guide to the state of shock or, rather, to the state of the patient as regards any surgical interference. Is it in any sense a guide as to what can be done for the patient?

The next question is the choice and administration of the anæsthetic. Assuming that one has given all possible treatment and that the time is ripe to do something for a man who had got a large cut right through the thickness perhaps of both cheeks, what form of anæsthetic is to be given? One cannot put on a mask, and one is a little bit nervous about trying to pass a tube through the nose, possibly burned. My temptation has been to try an intravenous anæsthetic or a rectal anæsthetic. But on one occasion we were giving pentothal to a burned, wounded man, and he died after 3 c.c. had been slowly injected, before he was touched surgically. A second case in which pentothal was given died rather inexplicitly the next day, and here the barbiturate may have been a factor. Rather than employ this type of anæsthesia in these cases of severe burns combined with facial wounds it is worth while considering a tracheotomy.

On this question of shock and toxæmia it is difficult to decide. If the man is shocked and wounded one can relieve his pain by surgery, but will surgery increase his shock ? I do not think in terms of shock in dealing with these particular people, but in terms of their pulse-rate, their blood-pressure, and their body fluids. We must regard the individual patient with his individual injuries. One case was that of a man who had crashed fairly close to his aerodrome. I saw him within two hours. He was badly burned about the face and hands, and he also had a fractured humerus, ulna, and metacarpal bone, and a compound and simple fracture of one tibia. In that type of case it was necessary to administer open ether and treat both burns and fractures at once. On the following morning he was fairly well, and he has never since given any cause for alarm.

In trying to solve the problem of these cases each patient must be regarded individually until the pathologists can give us some definite criterion that will help us to decide. Again, when dealing with facial burns we must think of the patient not only in terms of life but of living, and of the kind of face he is likely to be left with if one runs away from the problem and says: " This man is too bad to touch ". With the aid of dried serum and, less satisfactorily, with serum wet, we can deal with wounds in which a year or two ago there would have been little hope of securing a good result.

It is my duty to thank the Director General of the R.A.F. Medical Service for permission to make use of service case records, and also my duty to make it clear that the opinions expressed are solely my own.

Effects of Serum in Cases of Extensive Burns

Professor L. J. Witts *in absentia* (read by Dr. D. A. K. Black): During the past six months we have had the opportunity of observing the effects of plasma or serum in a number of patients with extensive burns. To avoid complicating factors, therapeutic agents like cortin or pituitrin, which might modify the blood findings, were withheld. The object of treatment with serum or plasma is to maintain the volume of circulating blood during the period when fluid is being lost into the burnt area, and so to prevent these irreversible changes in the tissues, which would occur if tissue blood supply were insufficient over a period of some hours; for this purpose a protein-containing infusion is necessary, as saline or glucose solutions leave the circulation very rapidly indeed in a shocked patient.

In patients with burns, signs of shock may be present within an hour of the incident, and the period of danger *from shock* appears to last for some twenty-four or forty-eight hours; thereafter, a fatal issue is not likely to be due to shock, but to toxæmia or to pneumonia. It has therefore been our practice to commence treatment with plasma as

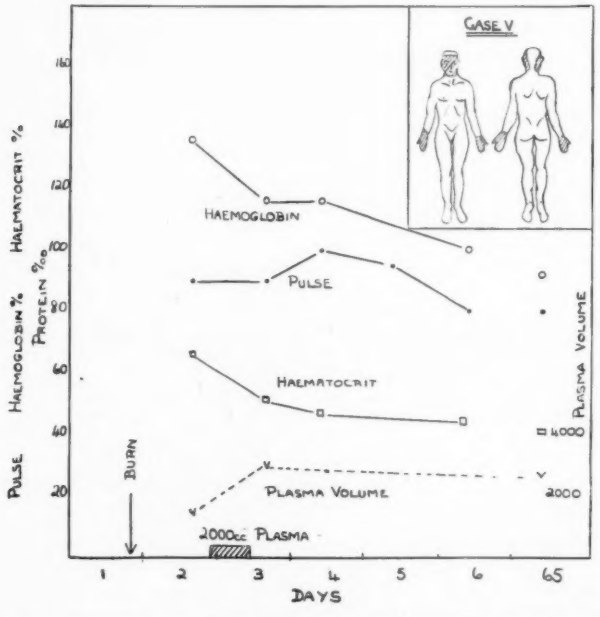


FIG. 1.—Rise in plasma volume, and decrease in hæmoconcentration, after plasma infusion.

soon as possible after admission. The plasma drip is maintained during local treatment of the burns, and for some hours longer; but intravenous administration of fluid was not prolonged after the second day, by which time the patients were able to take adequate quantities of fluid by mouth.

We have used both citrated plasma from M.R.C. bottles, and reconstituted dried serum: the only relevant difference between these two infusions is that citrated plasma has about half the protein concentration of true plasma, while reconstituted serum as used by us contained four times as much protein as true plasma. It has been suggested that there is an advantage in giving concentrated protein solutions, in that they may lead to recovery of some of the fluid lost into the neighbourhood of the burn, but in our patients the results with concentrated serum were definitely poorer. In two cases it was

necessary to supplement the serum infusion with one of plasma, as blood dilution had failed to occur, while the third patient who had serum died.

The administration of plasma or serum was followed by a very definite and striking clinical improvement in all the patients, except in one woman who was burned over almost the entire body. Peripheral cyanosis disappeared, the veins filled out, and mental apathy gave place to alertness. Patients were better able to take fluids by mouth, and to retain them. The blood-pressure rose, and the pulse increased in volume, although the rate often remained high in patients who were extensively burned.

Hæmoconcentration was present in all the patients, and initial readings of over 120% of Hb. were not uncommon. Plasma infusion was followed by a fall in Hb., red cell count and hæmatocrit %, to near the normal figures. Two patients had their plasma volume estimated by the dye method on several occasions; increase was observed, though less in amount than the quantity of plasma given, indicating that exudation was continuing. Concentrated serum was much less effective than citrated plasma in producing hæmo-dilution.

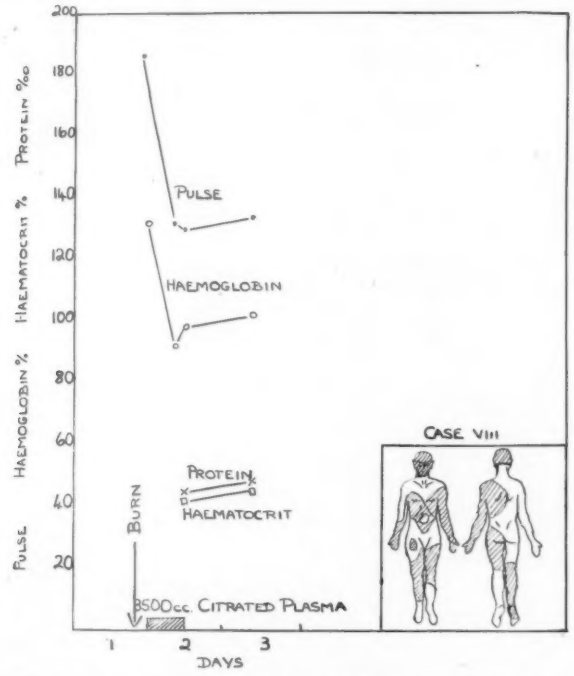


FIG. 2.—Fall in pulse-rate and hæmoglobin after plasma infusion, in a patient with extensive burns, who died from toxæmia on the third day after the burn.

On the basis of the patients so far treated, we can offer some suggestions as to the indications for plasma and the optimum dosage. Plasma is indicated where there are any signs of shock, such as pallor, collapsed veins, peripheral coldness or cyanosis, or fall in blood-pressure; the earliest sign of all is a rise in hæmoglobin, and we consider that plasma is indicated in any patient whose Hb. exceeds by 10% its likely previous value; in the majority of patients with burns—young healthy adults—this can be taken as 100. Some help as regards dosage can also be obtained from the Hb. reading. If we assume a normal Hb. of 100% and a blood volume of 5 litres, the deficit in plasma is given by the formula

Hb. : 100 = 5 : 5-x, where x is the amount of plasma lost, and Hb. the observed hæmoglobin. It is suggested that Hb. should be determined on admission, and the calculated plasma deficit run in rapidly by cannula while the burns are being cleaned and tanned. The Hb. estimation is then repeated, and more plasma run in by slow drip until the Hb. has fallen to normal. As soon as this has occurred the drip is stopped, and patients are given fluid freely by mouth, the fluid balance being charted. Our results after adopting this simple routine have been better, as regards shock, than in the earlier patients, in whom the dose of plasma was purely empirical.

The Functional Aspect of Burn Therapy

Professor A. H. McIndoe : The treatment of burns is a threefold matter, namely, the saving of life, the local treatment of the burnt areas, and the preservation of function in the parts involved. The saving of life is largely concerned with the treatment of burn shock and toxæmia, and it is obvious that the great strides made in serum and plasma therapy, and the use of coagulation treatment have greatly altered the outlook for the extensively burned patient. The question of the local treatment of the burns is more debatable. The evidence under war conditions is that the easily applied coagulation method, so successful in the prevention of toxæmia, has been carried too far, particularly in special areas of functional importance and where shock and toxæmia are not in evidence. This is particularly so of those coagulants which form a hard inelastic crust. Where the loss of skin is first or second degree (i.e. epidermal, dermo-epidermal or partial skin loss) the coagulation method gives excellent result providing sepsis can be excluded. Healing occurs rapidly from multiple focal points in ten to fourteen days. But where the loss of skin is third degree (full thickness) coagulation may and usually does fail particularly in regard to ultimate function. In these cases involving the whole thickness of the skin it is impossible to coagulate the entire burnt area. Sepsis inevitably occurs beneath the superficial coagulated layer with the result that months may elapse before separation of the slough takes place. Healing must occur from the edges of the resultant defect. Mr. Vaughan Hudson has compared this condition of third degree burns under tannic acid with the primary suture without drainage of infected wounds. Eventually a heavily infected granulating surface is exposed in which healing may be slowly and painfully achieved by dense scar tissue. During this phase the patient may become wasted and anæmic from chronic sepsis, broken in morale, and with such lowered general resistance that any question of grafting is impossible.

The preservation of function in the part burned is so intimately connected with the question of whole thickness or third degree skin loss that the two must be considered together. A first or second degree burn of enormous extent on the trunk or extremities treated by coagulation should result in complete healing with excellent function in ten to twenty days. A third degree burn in the same area treated in the same way means months of invalidism with eventual healing by scar tissue. There may be little functional disability because a keloid scar on the back or chest is not of much functional importance. These are the ordinary burns of civilian life ; but the same burns occurring in special areas such as the face and hands where function is of the highest import have an altogether different significance in relation to coagulation therapy, particularly where valuable service personnel is concerned. Totally crippled hands and severe facial deformities with loss of vision, which must be considered the direct result of the coagulation therapy and not of the burn, have too often been seen, and as most war-time burns involve the face and hands this problem is a serious one. When it is realized that a third degree burn produces a raw surface for which the best dressing is skin itself applied at the earliest possible moment we shall come nearest to reconciling treatment with function. The preservation of function therefore concerns chiefly the third degree burn, and all treatment in this type should be aimed at early removal of sloughs and the preparation of a bacteriologically suitable granulating surface to which skin grafts in some form can be applied. The wholesale tanning of burned surfaces is therefore inadvisable particularly in areas such as the hands and face. Judgment must be exercised in the careful diagnosis of the type of burn and the selection of cases for the most suitable form of treatment. For specialized treatment there is every indication for the segregation of cases of burns and their concentration with special units.

Valuable service personnel suffering from burns are being treated in widely scattered hospitals, some of them improperly equipped for the purpose. Delay occurring before the patient is brought under proper conditions has been responsible for many unfortunate results.

General Consideration of Burns

It is essential to distinguish between a partial and complete skin loss. In partial skin loss rapid regeneration is possible, in complete skin loss it is not. The diagnosis between them is easy at the two ends of the scale, i.e. between erythema with mild blistering and charring, or splitting of the whole skin down to the subcutaneous tissues, but it is difficult in that common type of case where severe second degree burns closely resemble third. Examination of the exposed dermis may decide the point. Any sign of dermal circulation, however slight, may mean that the depths of the papillæ have escaped. Blackened, wrinkled epidermis hanging from an opaque yellow-white dermis usually means a third degree burn with complete skin loss. Slight pressure on the dermis may produce blanching of the surface or bleeding may follow gentle rubbing. If either of these signs is present a partial skin loss should be presumed. The matter is made more difficult by dirt, oil or first-aid dressings. This is a good reason for discountenancing the use of coagulants at first-aid posts, for the diagnosis of the burn is all-important. Deeper burns than whole thickness skin destruction may occur, and in certain areas must influence prognosis, e.g. hands, face, flexures, &c.

Location of burn.—While burns of great extent are dangerous to life, those of lesser area may have no lethal meaning, but may seriously affect the function of the part involved. Thus an extensive burn of the trunk may put the patient's life in jeopardy, but, when healed in two or three weeks, may leave him without disability. Loss of a piece of skin the size of a postage stamp on the lower eyelid may produce rapid ectropion with exposure of the globe, corneal ulceration, perforation and blindness. The most crippling deformities of the hands may follow deep burns of small extent which give rise to no anxiety whatever as far as the patient's life is concerned. Treatment is thus determined by the depth and situation of the burn and its liability to sepsis, as well as by its extent and its danger from shock and toxæmia.

In this paper I shall deal only with burns in special areas.

The airman's burn.—This is a burn with almost unvarying characteristics, unlike anything seen in civilian life. It is due to sudden exposure of unprotected parts of the body to intense dry heat or to flame, as though the entire patient were thrust into a furnace for a few seconds and then withdrawn. It is rarely due to the burning of liquid petrol on local areas of skin. If this occurs a third degree burn is almost certain. The distribution is characteristic:—

(*a*) Both wrists and hands, particularly the backs and fingers. If gloves have been worn only the wrists are involved. The depth varies with the time of exposure.

(*b*) The face in the "helmet area". When goggles are pushed back the forehead, head and eyebrows may be severely burned, but usually the eyelids near the lash edges escape. The eyes themselves are not often burned. The area round the mouth and nose covered by the oxygen mask also escapes. The cheeks and ears are frequently involved.

(*c*) The neck between the chin and the collar extending on both sides to the mastoid regions.

(*d*) The anterior surface of the thighs if the trousers are thin; the lower legs between the trousers and the boot tops if flying boots are not properly adjusted. These areas are less often involved than the hands, face, and neck, and shock and toxæmia are slight.

The importance of the distribution and extent of this type of burn lies in the fact that the special areas involved demand and can receive particular treatment, for the possibility of functional disability is strong.

Subsequent Function in Relation to Depth of Burn

The end-results of partial skin losses (first and second degree burns) are excellent, since healing occurs by regeneration of epithelium within ten to twenty-one days, provided sepsis is excluded. Scar tissue contraction is absent and deformities do not occur. This is

the type of burn most commonly seen in the war so far, and the results following almost any sort of treatment have been uniformly good.

Third degree burns involving the entire thickness of the skin, or second degree converted to third degree by sepsis under a tannic acid coagulum must result in raw surfaces as soon as the slough has separated. Judging by their incidence they form a formidable group of cases and can result in the most crippling deformities. This is unfortunately true of the two areas most exposed to burns, e.g. the hands and face. In terms of personal suffering, deformity and disfigurement, strain on the nursing staff as well as economic loss to the community, few injuries can compare with them. By careful selection of cases, however, and adequate treatment many disasters can be avoided. The problem here is really the early re-epithelialization of a raw surface in which the normal epithelial response is deficient owing to sepsis, poor underlying vascularity, and the depressed general condition of the patient. Finger-joints and tendons will become immovable if left to consolidate in the dense basic scar tissue of a granulating surface. Thus hands become crippled, eyelids retract, rapidly exposing the globe to external trauma, teeth are exposed by contractures of the lips with disastrous effect on their necks and enamel surfaces. Contraction bands across flexures produce the deformities so well known in every orthopædic department. These difficulties are particularly common in cases treated with tannic acid, which have become septic beneath the coagulum.

The Disadvantages and Dangers of Coagulation Therapy in Burns of Special Areas

Coagulants containing a tannin preparation, used as dressings at first-aid posts on burns of the hands and face have long been advocated. Experience shows, however, that they are usually applied hurriedly and inadequately over uncleansed burned surfaces, whatever the degree of the burn and that they seriously complicate the final diagnosis, cleansing and treatment undertaken in the hospital. It would be better if a simpler primary application such as gentian violet jelly were substituted. Though gentian violet is also a coagulant it has fewer disadvantages than tannic acid in this respect. An even better first-aid dressing would be a simple saline dressing covered with a waterproof material to prevent evaporation.

When tannic acid preparations are used as the final treatment on the hands the following series of events has been noted:—

(*a*) Limitation of movements of the finger-joints. The fingers are fixed in flexion during the time the crust is in situ. Not infrequently weeks elapse before this is removed and it may take months for the patient to make a fist. This has been encountered even where pressure effects are absent. It is the commonest serious sequel of tannic acid therapy.

(*b*) Pressure effects: œdema developing beneath the coagulum as a result of the burn immobilizes the tendon sheaths very early and this is a definite factor in causing fixation of the joints. Sepsis, when it occurs, further increases the œdema. The pressure is intensified by the fixed encrusted tan which does not yield with the increase in size of the hand. Embarrassment of the circulation of the fingers leads to crippling deformities such as spindle fingers, partial necrosis or even total loss of the digits. A common complication is pressure necrosis of the tissues overlying the proximal interphalangeal joints with perforation into the joints. The result is a fixed, clawed, useless hand. It is not fully appreciated that this chain of events can occur in burns of the second degree and that many of these are converted into third degree purely by pressure necrosis.

On the face the difficulties largely centre round the eyes and eyelids and are most marked in burns of the third degree. Pressure effects are not noted but the horny layer of tan on the eyelids may cause great difficulties where the eyes are damaged and require treatment. If the burn is of third degree, sepsis is inevitable and rapidly developing ectropion with exposure of the globe, corneal ulceration and perforation may occur beneath the coagulum. In these cases it is far from easy to get rid of the crusts.

The use of tannic acid on third degree burns generally is not advocated. Only the superficial layers of the slough are tanned and the deeper untanned areas must separate and autolyse as best they can. Septic absorption is not prevented and in fact is markedly increased, for sepsis of varying severity occurs in almost every case. The sloughs take too long to separate and the preparation of the underlying granulating surface for grafting is greatly delayed. Infection becomes thoroughly established in the granulations,

11.9.40.

Pilot officer. Burned 1.9.40. Admitted tanned 11.9.40. Note the tense swollen dorsum and the tight constricting bands round the wrists. The fingers are immovably set in the tannic acid coagulum. Severe pain requiring morphine gr. ¼ twice daily.

26.9.40.

Fifteen days later. Coagulum has been partly removed with considerable difficulty. Note that the burnt areas are healed. This was a second degree burn except for one or two small spots on the left hand.

11.11.40.

After nine weeks this is the range of flexion possible in the fingers. Movement from the beginning would have given full flexion at this time. A typical bad tannic acid result.

FIG. 1.—Tannic acid on the hands.

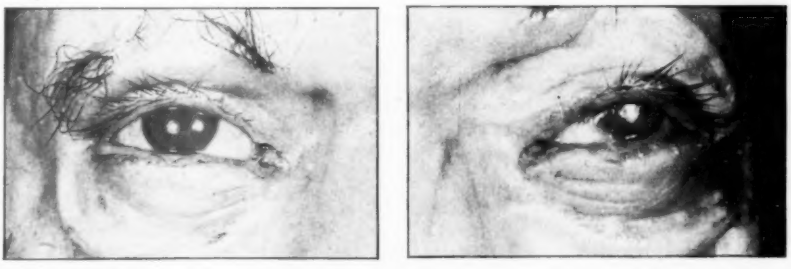
and their blood supply is impoverished owing to the increased density of the basic scar tissue layer. The epithelial response from the edges is practically absent. During this period of closed sepsis there is a steady decline in the morale and stamina of the patient.

FIG. 2.—Pilot officer, five weeks after receipt of encircling burn of both hands. Tannic acid applied and removed after three weeks. Severe pain during this period. Note that hands are completely healed except for third degree area on radial side right hand. Note pressure necrosis over knuckles of proximal interphalangeal joints and perforation into joints. The hands are wasted, clawed and immobile. They will probably remain so. This is a typically bad tannic acid result.

A. B.

A.—Pilot officer with " goggle burn ". The eyelids have escaped injury, the burn is of second degree, uninfected, and the result under tannic acid coagulation excellent.

B.—Pilot officer with third degree " goggle burn " involving eyelids. Tannic acid was used and great difficulty was experienced in dealing with the eyes which had been injured. It was not until the coagulum was removed that adequate treatment could be applied.



C.—Airman with similar third degree burn involving eyelids which had been tanned. Corneal ulceration followed ectropion beneath the coagulum which was removed with difficulty. Grafts applied as soon as possible but not before irremediable damage had been done. Note residual corneal opacities.

D.—Result following early grafting of ectropic upper and lower lids following burns. Cornea undamaged.

FIG. 3.—Tannic acid on the face.

The Saline Treatment of Burns in Special Areas

An alternative to coagulation therapy for these special types of burns is saline packs and baths. This might seem to be a return to the precoagulation era of painful dressings and demoralized patients, but all experienced plastic surgeons know that saline treatment can be carried out quite painlessly and is, in fact, not objected to by the patient. Expert nursing is required and the most rigid attention to detail, but the results fully repay the time and labour expended.

Hands.—The hands are immersed into small baths containing normal saline at 98° C. The patient is encouraged to move his fingers and wrist-joints in the saline solution ; two or three baths of one hour each are given during the day. Following the baths the affected parts are gently and carefully covered with tulle gras[1] and then sterile gauze soaked in normal saline is laid upon it, with no pressure, the latter being replaced every two hours without disturbing the underlying tulle gras. It is essential that dressings should not stick to the raw surface and on no account should wet dressings be left to dry and become adherent, as exquisite pain is caused on removal. The hands are then covered with a sterile towel, and supported on light wire splints. The position of the hands and wrists when at rest is important ; the wrist should be slightly dorsiflexed and the fingers kept slightly flexed, especially at the metacarpophalangeal joints. The outer dressing, but not the tulle gras, is removed prior to the subsequent baths, the tulle gras floating off in the saline solution. In this way painful dressings are avoided. Although no antiseptic solution is added, sepsis, if it occurs, clears up rapidly within one to two weeks and healthy granulation tissue develops. In some cases epithelial debris separate and form thin white layers over the underlying granulations or newly formed epithelium ; the debris should be removed by gentle swabbing and occasional addition of soap (pure soap-flakes) to the saline, or the hands may be given a thorough but gentle cleansing under a light gas and oxygen anæsthetic. This debris appears to be a potent nidus for the development of organisms, hence it is better removed.

Face.—Sufficient wool or jaconet is arranged around the neck to collect the drips, or a jaconet collar is fitted as described later. The eyelids and hairy parts are smeared with sterile vaselin. All loose pieces of burnt skin and debris are gently swabbed with wet wool and will come away without causing undue discomfort. A gamgee face-mask with an opening for the nose and/or mouth is prepared, soaked in normal saline and placed lightly on the face. The entire burnt area is covered. Over this is placed a jaconet cover with wool to retain the warmth and moisture. Every quarter of an hour further saline should be dripped on to the gamgee pad. This may be conveniently done through a drip from an irrigator can, preferably of the thermos flask type, and co-operative patients can often apply the intermittent irrigation themselves. If the patient requires cleaning up under an anæsthetic opportunity should be taken to clean off the debris more thoroughly. Soap (pure soap-flakes) and water may be used for the cleansing process. Fresh gamgee should be applied every twenty-four hours and if the old gamgee tends to stick, very light anæsthesia should be given and the tulle gras applied over the surface of the burn and saline treatment carried out. With a wide-meshed greasy dressing next to the skin the necessity for replenishing the moisture so frequently may not be so apparent. In certain patients, if a jaconet collar is satisfactorily applied there is no need to have a gamgee pad, the normal saline being flushed straight on to the face. For travelling purposes two or three layers of the tulle gras will make an efficient covering with some light gauze over it. Blisters should be dealt with as they arise.

To make the jaconet collar.—Make a hoop of wire roughly over 12 in. wide by 16 in. long. Cut a piece of jaconet large enough to cover the area and sag in the middle in the

[1]Tulle gras, originally a French preparation, may be prepared in the following way. Curtain net, with a mesh of 2 mm., is cut into pieces 9 cm. square. These are placed in a metal box slightly larger in size. The box is then filled with the following mixture :—

Soft paraffin,	96 grm.
Balsam of Peru,	2 grm.
Halibut oil,	2 grm.

sufficient to impregnate and cover the material completely after sterilization.

form of a bag 8 in. deep. At the neck end of the oval cut an opening large enough to slip over the head with ease. At the opposite end of the oval cut a drainhole at the most dependent part sufficiently large to take a rubber tube—in diameter about size 13. One end of this tube projects very slightly into the basin formed by the jaconet and is fixed in the hole with thread or elastoplast. The whole tube should be about 3 ft. long and drain into a convenient receptacle. The jaconet is attached to the wire frame by folding over a small hem and hemming it. Round the hole for the head, the edge of the jaconet is turned over and likewise hemmed, but the hem should be sufficiently large for a tape to run freely through it to tighten the collar round the neck. Further support to the front of the bib can be given by attaching the front of the frame to the pole supporting the irrigator. The attachment can be released when the bib is not in use.

Mixed Second and Third Degree Burns of the Body Generally

When the surface extent of the third degree burn involves wide areas of the trunk or thighs the best treatment is by the continuous constant temperature saline bath and if the hands and face are also involved these can be treated at the same time, by immersing the patient in a bath of saline. The bath is filled with thirty-two gallons of warm water to which is added one gallon of saturated solution of salt. This gives 0·9% solution. Warm water, to which is added automatically sufficient salt to form a physiological solution, runs into the bath at the rate of one gallon per minute, by means of an automatic device emptying into the head end. A similar quantity of water is allowed to run out from the bottom of the bath by means of a specially arranged valve. The temperature of the water is controlled by a thermostat. The patient is left in the bath ½ - 1 hour or longer if comfortable. He is then returned to bed and placed on sterile towels under a heated tented bed. The bed is wheeled alongside the bath for this purpose. The burnt areas are covered with a single layer of tulle gras, which in turn is overlaid with gauze soaked in saline. The raw surface should not be allowed to dry or pain will be produced.

The normal skin, especially in the vicinity of the burn, may become sodden from the immersion in saline. This can be avoided by interrupting the baths for one or two days at the end of a week. In burns of second and third degree new epithelium growing from the periphery and from central islands appears at the end of ten to fourteen days and spreads rapidly. The greasy layer from the tulle gras is removed occasionally by gentle wiping with saline gauze. In purely third degree burns the raw surface becomes clean and healthy granulation tissue appears towards the third week. The epithelial response from the edges is remarkably rapid and progresses steadily. As soon as possible skin grafting by the most suitable method is undertaken.

During all this time joint movements have been encouraged and thus stiffening is avoided and contractures are minimized.

The Use of Plaster and Vaselin

This method employed in the treatment of wounds is occasionally applicable to burns at certain stages. It should be reserved for third degree burns of the limbs, in cases where sepsis, pain and toxæmia have undermined the patient's morale so that he cannot tolerate the more elaborate forms of treatment. In such cases a general anæsthetic must be given : the burnt areas are then cleaned, debris removed, burned or necrotic tissue excised and the cleaned areas wrapped in vaselin gauze. Plaster of Paris is then applied in the usual way. By this method all dressings are avoided, rest and relief of pain is obtained. At the end of two or three weeks the plaster is removed and the burn inspected. Reapplication of plaster for a further period of two weeks or skin grafting will then be carried out, according to the degree of healing obtained. It may be possible to resume bath treatment.

The Late Treatment of Raw Surfaces

The control of infection and the preparation of the raw surface for grafting are matters for skilful and devoted nursing. Efficient treatment is at the same time the best stimulus to epithelialization, as has already been indicated. There is no easy road by antiseptics or dressings occasionally applied, and, in the full thickness skin loss, all efforts must be directed to " reconditioning " the surface for the application of grafts. This should be possible from the fourth to sixth week. The disappearance of pain is an excellent indication of

the control of infection and the correct moment to apply grafts is decided by the clinical appearance of the raw surface and the character of the discharge. Such a criterion as the bacterial count has been found in actual practice to be misleading, though a knowledge of the bacterial flora is of value.

If a third degree burn is of such a localized nature that it can immediately be excised and grafted, a long period of disability can be avoided. In this way a burn loss is transformed into a traumatic loss by excision with consequent improvement in the healing outlook.

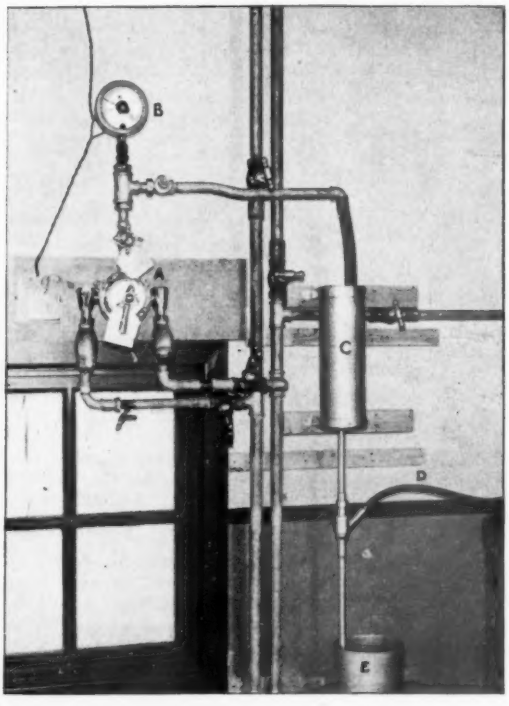


FIG. 4.—Saline bath mechanism. Hot water passes through a mixing valve A. The temperature is controlled by the thermostat B, at 105° F. The water runs into the container C, at the rate of 1 gallon per minute. When C is filled it discharges automatically into the container E, and during its passage draws enough saturated brine solution from a tank through pipe D to make normal saline. From E the normal saline is discharged into the bath in a constant stream at 100° F.

Under war conditions the most generally useful free grafts for raw surfaces are: (*a*) Small deep grafts (Staige Davis); (*b*) thin razor grafts (Ollier, Thiersch); (*c*) thick razor grafts—intermediate or split skin grafts. By a judicious use of one of these almost any loss of skin can be satisfactorily replaced.

The actual technique of grafting is in the province of the plastic surgeon, and it is advisable that the work be carried out in Units specially designed for the purpose. The patient can be transferred there by ambulance when it is considered necessary.

[This work has been carried out at the East Grinstead Maxillo-facial Unit. I am indebted to Mr. Skinner of the Office of Works for the ingenious construction of the constant temperature saline bath and to the Staff of the Hospital for their enthusiastic help in this difficult field.]

Envelope Method of Treating Burns

Surgeon Lieut.-Commander John Bunyan, R.N.V.R.—At the outset it must be stressed that the envelope method of burn therapy is in its early stages, and although the treatment appears to give most encouraging results, much work has yet to be done. Only the urgency of the problem of war burns has justified such early publication. It would appear that the five essentials for the healing of wounds of all kinds are: (1) Non-traumatic mechanical cleansing; (2) dissolving and washing away of dead organic matter; (3) transudation and removal of stale corrupted serum from injured tissue; (4) the attraction of new healthy serum to the injured tissue; (5) destruction of any remaining bacteria.

At the same time a satisfactory form of therapy must fulfil the following requirements: (1) Treatment must be painless and relieve existing pain; (2) should not necessitate the use of general anæsthesia; (3) no preparation should be used which produces toxic matter or otherwise injures healing tissue; (4) protective dressings should require the minimum of interference; (5) dressing must prevent all possibility of secondary infection.

The treatment of burns demands in addition the following special conditions: (1) Avoidance of aggravation of primary shock; (2) prevention of acute toxæmia from breaking down of damaged tissue; (3) primary disinfection and prevention of secondary infection; (4) control of loss of body fluids and salts from burnt areas; (5) stimulation of new tissue growth without production of scarring.

The treatment that satisfies the above requirements most closely is intermittent irrigation with weak solutions of electrolytic hypochlorites. The properties of these solutions are: (1) Selective action—the solution of dead tissue and stimulation of healing tissue; (2) the breakdown products are salt and oxygen; (3) great bactericidal powers in non-irritant concentrations; (4) stability and constant strength of stock solutions; (5) relief of pain and desensitization.

The treatment consists of :—

(*a*) A hosing down of the burnt area by a 5% solution of electrolytic hypochlorite at 100° F. which removes all surface contamination, much of the charred tissue, all the exudates, and kills most of the bacteria present.

(*b*) The application of the appropriate coated-silk envelope to the burned limb or part for irrigation.

The envelopes are made of a fine pure silk cloth coated with synthetic resins which are unaffected by hypochlorites or boiling, and render the silk watertight.

The most suitable shapes have been designed for application to any part of the body. There is an entry and exit, and the open part of the envelope is sealed to the body by a combination of specially prepared adhesive silk strapping and rubber or pneumatic bands. Sealing is not a difficult operation, and providing attention is given to every detail, a satisfactory watertight seal can be made in nearly every case.

In the case of very extensive burns where complete immersion of a large part of the body is necessary, a portable collapsible bath has been designed and built. Its advantage is that it can be used anywhere, and after irrigation becomes the bed, so that there can be little possibility of secondary infection. As in the case of the envelope it is also the sole dressing.

(*c*) *Irrigation.—Solutions:* (*a*) Normal saline at 100° F. It has been found that normal saline is too strong, and we now use sterile water at 100° F. (*b*) Normal saline to which is added sufficient electrolytic hypochlorite (containing 1% sodium hypochlorite) to make a 5% solution (1 oz. hypochlorite to 20 oz. saline). The saline container is labelled "blue" and the hypochlorite "red" in order to differentiate easily.

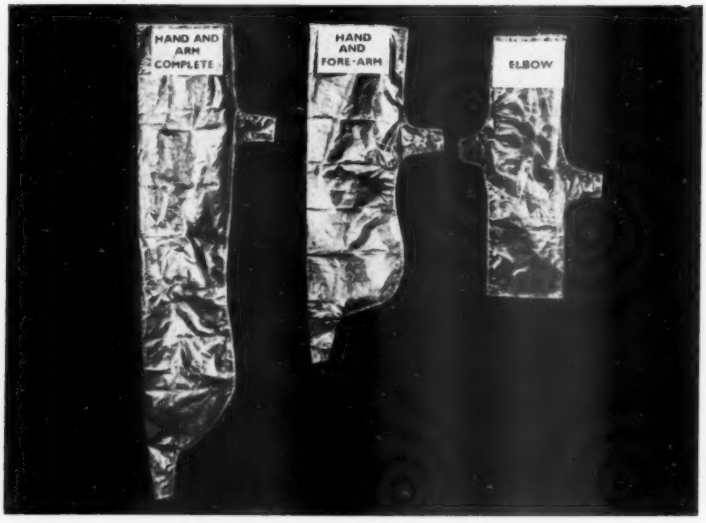


FIG. 1.—Bunyan-Stannard Envelopes for upper limb.

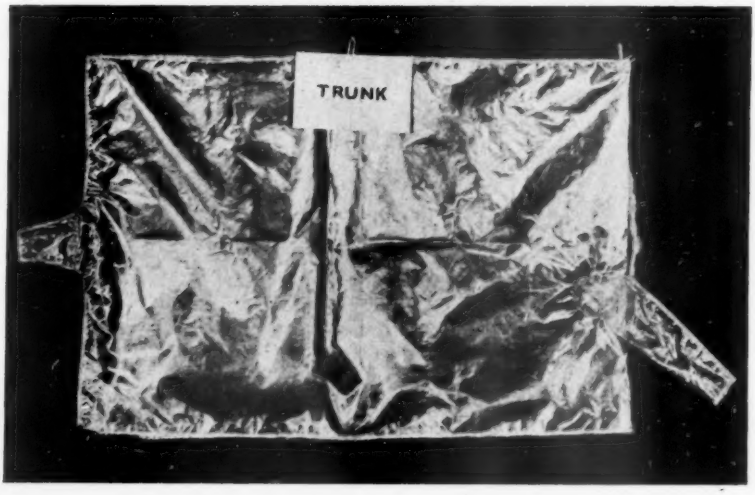


FIG. 2.—Envelope for trunk.

FIG. 3.—Envelopes for lower limb.

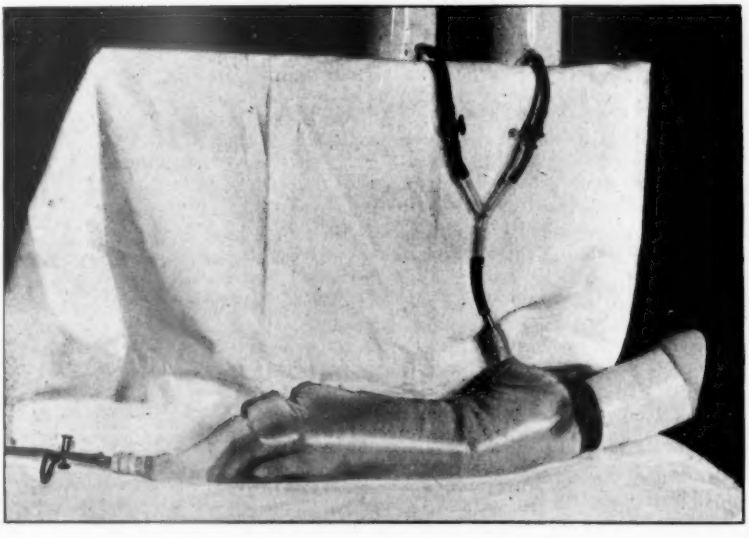


FIG. 4.—Method of introducing fluid into the envelope.

Method: The containers are suspended above the patient, connected by a Y tube and lead to the envelope. The saline is run in first flowing over the burn. When the envelope is half full the saline-hypochlorite solution is added to the saline in the envelope until the final concentration of hypochlorite in the envelope is about 2-2½%—a concentration which can be tolerated easily by most patients. The envelope is slowly agitated to give a flowing motion to the fluid, and after twenty minutes is run out. The irrigation is done three times a day during the infected stage, and twice daily when infection has ceased. Between irrigation the wound is left undisturbed, as any stale exudate having been taken away the fresh exudate is allowed to proceed with healing without interference.

During the washing, further hypochlorite is added to make up for that destroyed by combination with the dead organic matter. Wherever possible, a continuous flow should be arranged. Many combinations of solutions can be used, but space does not permit of their inclusion in this paper. The envelope remains undisturbed until the burned area has epithelialized over completely, or until the area is ready for grafting.

From the cases treated in this manner it is possible to formulate a list of claims with some certainty. They are discussed under the following headings:—

Primary shock.—Since the cleansing is painless and does not stimulate the nerve endings, no general anæsthetic is required except in the most extensive burns. The envelopes can, in most cases, be put on and sealed without touching the burn at all. Disinfection can proceed without the patient being aware of any treatment occurring, so that he can be given all the aids to resuscitation without interference.

Secondary shock.—Owing to the removal of any irritant matter which might keep up the capillary dilatation, loss of body fluids and protein should be minimized. It has been noticeable that the exudation from the burn decreases very rapidly on irrigation with hypochlorites.

Disinfection and prevention of secondary infection.—The very high bactericidal powers of electrolytic hypochlorites in solutions which are completely harmless, and which can stimulate healing, deserve more recognition. In the cases to be described, a constant factor is the almost immediate cessation of toxic symptoms as shown by the bringing down of temperature and pulse to normal. That the envelope prevents secondary infection is shown by the normal temperature and by the rapidity of healing. In one case where the envelope was taken off just before all the area had epithelialized, infection occurred immediately.

Tissue toxæmia.—This is prevented by the fact that the hypochlorite immediately acts on the damaged tissue. Although the solution of dead tissue is not immediate, the hypochlorite will break up the products formed by autolysis into an innocuous solution which is washed away, or it will restore tissue capable of healing.

The possibility of maceration and irritation has been raised. We have seen no maceration from the use of hypochlorites except where there is much hard thick skin. This has never been sore, however. Saline causes severe maceration and irritation. If it is desirable that the limb should be dried, warm oxygen may be blown through.

The general advantages of the envelope treatment are:—

(1) It can be applied quickly and easily without complicated apparatus.

(2) Because the application of the envelope and treatment are painless, and because changing of dressing does not occur, mental trauma is banished.

(3) The question of whether epithelialization should be allowed to proceed or whether grafting should be carried out as soon as the wound is rendered healthy cannot be settled until the results are seen many months after the completion of the treatment. This question is therefore left entirely to the expert plastic surgeon to decide. We can say, however, that the envelope method will be of great assistance in preparing a healthy base for the graft and for preventing infection after the grafting operation.

(4) The envelope allows of free movement of the limb without the fear of pain. This in itself will prevent much of the deformity seen in other methods of treatment.

(5) Because of the disinfection and actual prevention of toxæmia, chemotherapy is rendered unnecessary.

(6) The covered silk is transparent and the progress of healing can be observed throughout.

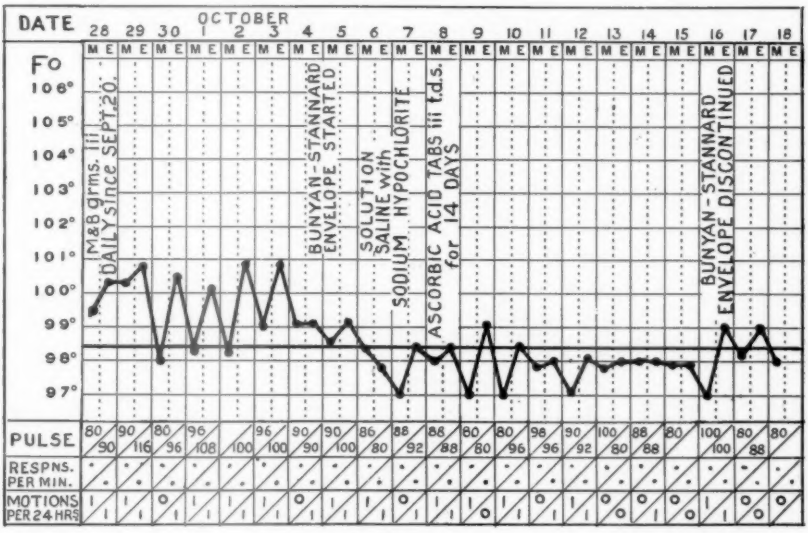
(7) The nursing of the case is much simplified ; an important point when skilled nursing is not easily obtainable.

(8) Far less time will be required in hospital—indeed many cases may well be treated as out-patients or at home after the stage of primary shock is passed.

(9) Although the envelope was originally designed for using hypochlorites, there are many forms of treatment which may be used, such as certain oils, gases, waxes, &c. We do not agree that saline by itself, particularly as a continuous bath, is a suitable medium by the envelope method.

(10) In the difficult cases where fractures exist as well as burns, the method appears to offer a solution. Treatment of ordinary compound fractures has proved successful so far.

Case 1.—Third degree burn from elbow to finger-tips. Patient given saline baths twice daily and dressed tulle gras. Temperature 98-101° F. daily. Burn painful after



CASE 1.—Battle casualty.

midnight until morning dressing. Did not move fingers in bath owing to fear of touching sides which caused extreme pain. Excitable.

Envelope put on 11.30 a.m. filled with saline; result : thick solution of exudate and bacteria. This was changed at 3.30 p.m. and saline and 2½% electrolytic hypochlorites substituted. Drained after half an hour. Repeated at 7 p.m. Patient asleep without drugs at 9 p.m., temperature and pulse normal. Next morning patient very comfortable, temperature and pulse normal.

Irrigation of saline and 2½% electrolytic hypochlorites t.d.s. Within forty-eight hours patient was completely confident and moved his fingers and hand freely, no pain. Temperature and pulse continued normal. At the end of ten days the arm was epithelialized except for two knuckles and the point of the elbow. Envelope was removed too soon and resulted in immediate reinfection of the new areas. This was overcome and the patient healed rapidly.

Case 2.—Résumé of Matron's Report.

The patient, a child of 10 years, was admitted to the Children's Ward of the General Infirmary, Macclesfield, on March 31, 1940. She was suffering severely from shock due to severe burns of body from manubrium sterni to pubic area, neck and arms.

Later a general anæsthetic was given, the wounds cleansed and tannic acid solution 2·5% sprayed on.

This formed a good skin which, however, became septic after three days; temperature rose and pulse again became rapid. The crust was removed and a fresh solution of tannic acid was applied. This was done on the fourth day, again under a general anæsthetic. Streptocide tablets 1 t.d.s. were given (0·5 grm.) for four days until the temperature subsided.

The second skin again became septic on the trunk and the temperature rose with a rapid pulse-rate; the general condition was low. Streptocide tablets were given again for another four days and the child started to vomit continuously. Rectal saline was given four-hourly during the day and twice during the night. Streptocide was discontinued after four days, but vomiting lasted continually for eight days.

Tannafax jelly was applied after removing the second skin of tannic acid solution, this also had to be removed owing to infection. The neck and both arms took the second skin of tannic acid solution fairly well, and, though septic, slowly improved. The elbows of both arms had to be put into splints to avoid contracture. The splints were removed twice daily for exercises.

The trunk did not improve and normal saline dressings were applied; these were soaked four-hourly in normal saline, but there was no progress. After seven weeks, there was again a sudden sharp rise of temperature from 99° F. to 104° F. The area of the abdomen and chest became very tender and raw. Ultra-violet ray was then given with no success.

Dressings from the commencement of the case were an agony to the child.

Acriflavine emulsion was next applied. There was some slight healing. General condition improved, temperature became normal.

After twenty-nine weeks, on October 11, 1940, a new treatment was tried; this consisted of totally enclosing the wound in a delicate, transparent, waterproof silk fabric, which was sterilized. It was then sealed with special adhesive around the chest at the upper edge and round the abdomen at the lower edge, having an inlet and an outlet for the lotions.

The patient was extremely apprehensive of this new dressing. Normal saline at a temperature of 105° F. was slowly poured in through the inlet to cover the wound, and the child did not feel pain. This saline was run off from the outlet and carried much exudate with it, and fresh saline was poured in. When the area was again covered hypochlorite 2½% was run in.

Again there was no pain. This treatment of washing the area with normal saline and hypochlorite was carried out three times daily, with meticulous care as to detail of percentage of solution and temperature.

The child now turns happily in bed, feels no discomfort with the silk garment left emptied but moist and seems to like the touch of the silk. Her general condition is excellent.

The rapid regeneration of the epithelium is noteworthy. All the time the state of the skin can be seen through the silk.

Original extent of burnt surface, March 31, 1940: 10½ in. across chest; 15½ in. down left side; 8 in. down right side; 11½ in. across lower abdomen.

November 4, 1940: Extent across chest 9 in.; extent down chest 4 in.

November 17. Triangle size: 2¼ in. by 6 in.

Conclusion.

It is felt that this method is worthy of extended trial. It appears to conform more closely to the rules that have been formulated than any other method, and the results so far encourage us to perfect both the envelope and the treatment.

I would like to acknowledge my great indebtedness to Mr. William Stannard of Leek for his keenness and technical skill and for bearing the cost of the experiments which were necessary to make the idea a practical proposition; to Admiral Wakeley, Mr. W. H. Ogilvie, for their encouragement, Sir Harold Gillies for making it possible to treat some of the first cases, and Dr. Gillies of Macclesfield and the matron and nurses of Macclesfield Infirmary for their kind co-operation.

Lieut.-Commander Bunyan then showed a coloured film of treatment by the envelope method.

Sir Harold Gillies emphasized the value of local treatment of burns, and the necessity for team work. They had to get together to make these hopelessly deformed hands and faces better. Some other treatment than tannic acid for the hands was indicated. Saline treatment was made easier and possibly more efficient by the Bunyan-Stannard envelope. They should be grateful to the people who had introduced serum and even more grateful to those who had introduced the sulphonamide compounds. There was also a new paste

which Professor A. J. Clark in conjunction with A. B. Wallace of Edinburgh had had made up containing albucid 5% in glycerine and cod-liver oil and kaolin. That paste might be of use in this treatment. Col. Colebrook had assisted in the local treatment of these granulating areas by powdered sulphanilamide. He felt that it was their bounden duty to get better results in the case of these burned hands and faces by using every available method.

Mr. R. Vaughan Hudson (Middlesex Hospital) said that a burn should be regarded as a wound. If tannic acid were applied to a burnt area, it would be exactly the same as primary suture of a surgical wound without drainage. Skin, provided that it was not completely destroyed, had an automatic power of regeneration. If it were completely destroyed it could only be replaced by granulation tissue and scar tissue or by skin brought from another part of the body. He believed that it was necessary to revise our treatment of burns and apply the principles underlying the surgical treatment of wounds.

Col. Leonard Colebrook said that sepsis was one of the main factors in the burns problem and it resolved itself chiefly into infections by the hæmolytic streptococcus. Surgeon Rear-Admiral Wakeley had said that he considered it rarely necessary to administer sulphanilamide when sepsis was present. On the other hand, Sir Harold Gillies had suggested that there was a great future for the sulphonamides in connexion with burns. He agreed with Sir Harold Gillies in this and gave his reasons for thinking that there was great hope in the local application of sulphanilamide either in powder or in some form of paste.

With the help of Sir Harold's colleagues and of Major Francis and Dr. Morley, he had recently observed a series of 35 superficial granulating wounds treated once a day with sulphanilamide powder under vaselin gauze and a moist saline dressing. In all but two of them the hæmolytic streptococci with which they were infected had disappeared within two or three days—sometimes within twenty-four hours.

He described a few of these cases. One had multiple lesions resulting from sulphuric acid burns. Hæmolytic streptococci grew from 10 of 15 swabs taken from these wounds on October 11 and 12. From October 15 sulphanilamide powder was applied once daily to all wounds. Six of the wounds previously yielding streptococci were swabbed on October 16, 18, 20 and 22 and three wounds on October 28. No streptococci were grown from any of these 27 swabs.

Another case had granulating ulcers on the dorsum of each hand—that on the left hand being much the larger. This hand was powdered once a day. From the left hand the streptococci (and *B. Proteus*) disappeared within three days and healing was rapid. On the right hand which had received routine treatment these organisms survived till healing of the small lesions was nearly complete after eight days.

In most cases healing had been rapid as soon as the streptococcus disappeared from the lesions.

Within the last two weeks he had seen a recent case with extensive second degree burns resulting from bomb flash. After a few days in saline baths all the burns were infected with hæmolytic streptococci, but following the application of sulphanilamide powder for three days these organisms had disappeared and the lesions were healed.

He was hopeful that many of the second degree burns in which there was not a great deal of effusion would show the same results. The method employed was to blow the powder on with an insufflator. It was particularly in cases without a great deal of suppuration and without sloughs that elimination of streptococci might be expected.

Mr. T. Pomfret Kilner said that at the Ministry of Pensions' Hospital there had been admitted only a few cases of burns from the present war. These and many cases seen after the last war bore out all that had been said about the crippling effects of burns on the hands and fingers. He had not employed saline baths in early stages but had found that wax baths at a later date rendered the finger skin more supple and increased the range of movement. He wondered if Mr. McIndoe had had as yet an opportunity of treating a hand burn by saline baths from the beginning and whether this treatment prevented the fingers from becoming attenuated, blue and fixed. Did he advocate encouragement of active movements throughout such treatment and how did he prevent stiffening of joints during the grafting stage when fixation was presumably essential to success ?

Mr. Kilner stressed the point that treatment of all facial injuries, burns most of all, should aim primarily at restoration of function. If sight was to be preserved, immediate protection must be provided for the eyes by early grafting of ectropic eyelids.

Mr. McIndoe, who was the only one of the openers who wished to reply, said in answer to Mr. Kilner that they had treated a number of acute cases with baths of saline from the beginning, and the results had been most impressive. It was true that if a third degree area resulted, immobilization was necessary for a graft. The immobilization, however, lasted only from seven to ten days, and certainly it did not seem to have the disastrous fixation effect which followed the early immobilization during the period of œdema and infection in the presence of tannic acid. Spindling of the fingers had not resulted.

Section of Medicine

President—SIR MAURICE CASSIDY, K.C.V.O., M.D.

[*November* 26, 1940]

DISCUSSION ON THE TREATMENT OF TRAUMATIC HÆMOTHORAX

Dr. F. G. Chandler: The "Official History of the War" ("Medical Services Surgery of the War", Vol. I) contains much of the greatest interest and value on wounds of the chest. The work of Gask, Gray, Lockwood, Nixon, and Duval, must not be forgotten.

Some of the literature of hæmothorax is not of the same value, and contains much that is false and speculative concerning diagnosis, physical signs, and treatment. In one work, written in 1915, the author, a surgeon, says "All are agreed that hæmothorax is the result of slow bleeding from the chest wall . . . and does not come from perforated lungs"; he is strongly opposed to the use of the syringe in all cases and advocates an attempt at absorption treatment by large doses of iodide of potassium.

There surely can be no doubt that the lung itself is frequently the source of the hæmothorax. As regards absorptive treatment by drugs, there must be few to-day who would hold it of any value. The exploring needle is essential for diagnosis and for the early detection of infection. It may have to be employed repeatedly. With proper technique it is without danger and should be practically painless. 2% novocain (procaine) can be used without stint and it must be applied to the two sensitive places, the skin (where a bleb should be made) and the pleura, which should be well infiltrated. After this, nothing whatever should be felt, no matter how large an instrument may have to be passed.

There is another matter to which I should like to refer and that is the tendency to comment with surprise on certain physical signs, and the temptation to speculate on the cause of their supposedly anomalous nature. The physical signs of hæmothorax are very variable, and may be most peculiar. They may even simulate those of pneumothorax, owing to widespread skodaic resonance. The exploring needle may have to decide the diagnosis. Bronchial breathing is well known to be a common physical sign of fluid, yet time and again it is hailed with surprise and contradictory theories are advanced to explain it. It is sufficient to accept the fact that with fluid, whether serous, pus or blood, bronchial breathing is a common phenomenon.

The value of radiology, both in diagnosis and the subsequent control of the case, cannot be exaggerated. In the "Official History of the War" (p. 216, vol. I) we read the following:—

> "It was soon evident that X-rays were of the very greatest value at the front, and were if anything even more important than at the base Hospital," . . . "The supply of X-ray equipment and of special officers was never equal to the demand . . . difficulties . . . remained to the very end of the War."

It is to be hoped that these difficulties will be overcome in the present war.

By traumatic hæmothorax we mean, in these days, war injuries. Nevertheless any experience based on accidents or on spontaneous hæmothorax will be of value.

The problem of treatment cannot be reduced to a simple formula, for the hæmothorax may be:—

(1) Simple and non-infected.
(2) Infected.
(3) Complicated by many other factors.

(1) *Simple and non-infected*: (*a*) small, probably not requiring treatment, or (*b*) not small, demanding treatment. I would define a small hæmothorax as follows: physical signs of fluid at extreme base only; the skiagram showing fluid in the costophrenic sinus with the dome of the diaphragm visible. If the dome is nearly obscured there is probably half a pint of blood or more. This amount is approaching the second category, but I admit that the distinction is unfortunately, but unavoidably, very arbitrary.

(2) *Infected* : the infection being indicated by bacteriological examination, aerobic or anaerobic, or by odour or ? by massive clotting. If the blood withdrawn by the exploring syringe has any unpleasant odour, it must be assumed to be infected, no matter what the bacteriological report, and treated accordingly without delay. There must be no waiting for evidence of toxæmia. Delay in recognition and treatment by efficient drainage greatly increased the mortality in the last war. Many cases of infected hæmothorax "were at first (p. 353, vol. I) erroneously diagnosed, the change for the worse in the patient's condition being ascribed to a pneumonia, or even to renewed hæmorrhage or to the development of a pneumothorax, when in reality the infection had led to an increasing effusion of fluid or to the formation of gas by the action of anaerobic bacilli. Such a wrong diagnosis meant that the patient was kept quiet and disturbed as little as possible, when he very soon died".

The temperature may be no guide ; it is frequently raised for four days or more with a simple hæmothorax. Whether massive blood clotting (sometimes a difficult matter to prove) should be regarded as a sign of infection and an indication for an open operation and removal of clots, or closed drainage by an intercostal catheter, or attempts at aspiration through a large cannula, may be a question suitable for discussion.

(3) *Complicated by other factors*, for example : open wound of thorax, indriven splinters of bone, missiles, clothing, &c., damage to lung with or without retained foreign body, pneumothorax, valvular or otherwise, perforation of diaphragm, injuries to other parts.

As the infected and complicated hæmothorax is a matter for the surgeon cognizant of the special problems of thoracic technique, I will leave this part of the subject to subsequent speakers, and will confine myself to the simple non-infected hæmothorax.

I will quote again from the "Official History of the War" (p. 359, vol. I) :—

> "Two conclusions emerged from this evidence. First that surgeons required training in the special principles of dealing with chest wounds, and secondly, that only a moderate proportion, perhaps 25%, of cases of gunshot wounds of the chest needed surgical treatment in the first forty-eight hours".

Treatment of simple, non-infected hæmothorax.—The first essentials in my opinion are rest and the treatment of shock, blood loss and pain, by the usual methods, the relief of cough and dyspnœa and the promotion of sleep. Some have advocated autotransfusion by the blood from the hæmothorax, but I must confess I do not like the idea, in spite of its ingenuity and apparent advantages, because of the possibility of latent infection.

M & B 693, prontosil, proseptasine, soluseptasine, rubiazol, sulphathiazole and allied chemicals, will probably be used in an attempt to limit or control or prevent infection in the lung and tissues generally, but from our experience with empyemas we shall not expect them entirely to prevent infection of the hæmothorax, nor to be effective once infection has occurred. Moreover their occasional depressing and nauseating effect may limit their use as a routine.

If the hæmothorax is small and uninfected, nothing more need be done ; otherwise, I advocate its early aspiration by air or oxygen replacement. By early I mean within twenty-four or forty-eight hours, unless urgent dyspnœa or extreme mediastinal displacement makes it imperative even earlier. J. E. H. Roberts in a recent publication ("War Wounds and Injuries", Fletcher and Raven, 1940, p. 42) expresses the opinion that the most favourable time is between the sixth and eighth days, but I doubt if it is necessary or advisable to wait so long, provided the replacement method is used. Actually, no optimum time can be given ; every case must be treated on its merits. Aspiration may be indicated in the first few hours or not for days. By the replacement method there is no disturbance of the mediastinum, no encouragement to further bleeding, and no danger. Early aspiration helps, I believe, to prevent loculation and possibly infection. If a considerable amount of blood be left, the sequelæ may be pleural thickening, non-expansion of lung, and calcification. After replacement, a skiagram of the lung may reveal foreign bodies which before were obscured by the overlying blood.

In the last war, at a casualty clearing station in the battles of Cambrai, where I encountered a number of cases of hæmothorax, I used oxygen replacement, but I doubt if this has any advantage over air, and it merely complicates the technique, though a

simple improvisation may be made by means of a Woulfe's bottle if oxygen is deemed preferable for any reason.

For aspiration the patient should lie comfortably on his back with the head and shoulders raised.

The point of entry of choice, from the point of view of the patient's comfort, is as low as possible between the mid-axillary and post-axillary lines, bearing in mind that the diaphragm is often temporarily paralysed and consequently high in the thorax.

After complete anæsthetization with 2% novocain (procaine), a small trocar or cannula is passed or a larger instrument, e.g. a thoracoscopic cannula, through which a soft rubber catheter may be passed. This may be of the straight type or one bent at a right angle ; this will straighten itself out when passed through the cannula and take on the right-angled bend when it enters the pleural cavity. With this type of catheter, the blood can be aspirated right down to the costophrenic sinus without moving the patient.

Air may be admitted through the aspirating needle or cannula, or through a fine needle inserted two interspaces higher. It can be left open to the atmosphere and covered by sterile gauze ; by this method the replacement by air is automatic.

There is no need to-day to stress the fact that *to aspirate any considerable quantity of fluid without admitting air is dangerous.* The slightest discomfort, a feeling of tightness, cough, are all indications that the pleural pressure is becoming dangerously negative.

It was my experience in the last war that the men tolerated the procedure extremely well and usually went to sleep while it was in progress.

After aspiration of all the blood possible, watch must be kept for the re-accumulation of fluid. This may be determined by physical signs, or by X-rays, preferably the latter. If there is a re-accumulation, exploratory puncture to determine the nature of the fluid is indicated.

When the patient's condition permits, breathing exercises to restore diaphragmatic movement and basal expansion are an essential part of the after-treatment.

Dr. Clifford Hoyle : During the last war it was found that a traumatic hæmothorax which remained sterile had practically no mortality after the first two days. The average period of invalidism for these patients was about three months. 5% left the Services, and the majority of the remainder became fit for full duty in less than six months. But infection was common, occurring in a third of all the patients, and for these the prospect was grim ; there was a mortality approaching 50% within a few weeks, with a third of the survivors leaving active service after seven months in hospital, and a fair number taking a year before returning to duty. Many of these kept the legacy of a collapsed lung and rigid thorax, and never became restored to health or to efficiency. Taking all these together with those who died within the first two days from hæmorrhage or from tension hæmothorax, and those late catastrophes which post-war figures never traced there is no doubt that the toll of traumatic hæmothorax was high.

The responsibility rested mainly with the frequency of infection, and the difficulty then experienced in dealing with it. We are now better informed of the circumstances which make infection within the thorax so harmful, and of these, four factors need special mention : traumatized lung tissue or a foreign body, an imperfectly excised and sutured sucking wound, an inadequately drained pleura, and failure of the lung to re-expand. The importance of the first of these conditions—the presence of traumatized lung tissue or of a foreign body—is so great that it properly forms the basis upon which the treatment of traumatic hæmothorax should be considered, as indeed it did among those experienced in the last war. Thus we distinguish simple hæmothorax from what, for convenience, I term compound hæmothorax, the latter term implying that the hæmothorax is accompanied by important injury to the lung or to the chest wall or by a retained foreign body which is regarded as significant. In the simple form the hæmothorax is the chief lesion ; it does well with conservative management, and operative measures are rarely needed ; in the compound form the hæmothorax is no more than an incident that happens to occur in a complicated injury, it does badly with conservative management, and operative measures are usually advisable. The importance of this basic distinction is all the greater now when thoracic surgery offers much more than expectant treatment.

The immediate object of investigation in these patients should be directed to making this distinction if it is possible to do so. They need careful clinical examination and as

accurate a history as circumstances allow of the way in which the injury was received; they need also careful supervision with a close watch upon the pulse-rate, respirations, colour, and general condition. And they need antero-posterior and lateral radiograms of satisfactory quality, including penetrating films; for metal fragments are readily overlooked if they are obscured by hæmothorax in a film of insufficient penetration.

Turning to the treatment it is convenient to deal with it under four headings: the early management during the period when shock and the effects of hæmothorax or of tension within the pleura are of chief importance; the subsequent management of the simple and compound hæmothorax; and the management of the infected hæmothorax.

The early management.—From the point of view of treatment during the first few hours all patients with hæmothorax can be grouped together, for the initial shock of the injury has to be controlled, the effects of hæmorrhage overcome, and pleural tension relieved. They should be rested in a sitting position if there is any respiratory difficulty, but otherwise, especially if shock is severe, recumbency is better. Morphine is needed for the relief of pain and anxiety, and for securing sleep; Herringham, writing of his experiences at a casualty clearing station during the last war, remarked that he never saw morphine do harm. Only if there is much associated hæmoptysis should morphine be used with caution, for then it may well favour the aspiration of blood into the opposite bronchial tree and lead to collapse of the lower lobe on that side. Morphine, by relieving pain, may actually facilitate cough after a chest injury, and at any rate with a large hæmothorax the danger that cough may produce further bleeding is not material. Another point is that these patients need all the reassurance that we can give them, and as a help to this there is a useful place in treatment for hyoscine and phenobarbitone.

Transfusion is required for large effusions, especially if they have accumulated rapidly. Blood is preferable to plasma, although in an emergency a transfusion can be started with plasma while the patient is being matched. Recent experience has seemed to show that direct matching is essential even when stored blood is used, for otherwise reactions are frequent, and can be very disturbing. Quite a large hæmothorax can be tolerated without much dyspnœa provided that it accumulates slowly, but if there is any evidence of increased intrapleural pressure the blood should be removed by aspiration with air replacement. This technique is essential for such patients in order to control the intrapleural pressure and the position of the mediastinum, and also to avoid risk that the injured lung will re-expand suddenly, perhaps with a resulting further hæmorrhage or a spontaneous pneumothorax. The amount of air introduced is of course less than the amount of blood removed in such cases, and has to be gauged individually. Air replacement has another advantage, that if further bleeding into the pleura does occur it can be readily recognized subsequently.

Sulphonamides should be given as soon as possible, and in amounts advised for other war injuries. Whether they will prove to be as valuable in the prevention of infection in the pleura as in the lung remains to be seen. So far they do not appear to have materially altered the liability to infected hæmothorax.

Simple hæmothorax.—A simple hæmothorax or hæmo-pneumothorax may be found after a small penetrating wound of the chest without at any time having led to noticeable symptoms. It may indeed be found accidentally without any other evidence of a chest injury. Whatever the symptoms or size a sample of the blood should be obtained to confirm the diagnosis, which is by no means always easy without needling, and also to exclude infection. For this smears should be made at the time, with a culture report following. It is not accurate to assume that a hæmothorax is uninfected because there is no change in colour, no laking, or no smell; infection, unless it is a mixed one, does not always produce such changes early on.

Apart from the removal of blood for mechanical reasons already mentioned there are other good reasons why a simple hæmothorax should be treated as a routine by air replacement. One of the most important is the lengthy time that is required for such effusions to absorb—a process which takes weeks or months if left to nature can be effected in less than an hour by aspiration with air replacement. Again, because infection is so prone to attack the pleura in these patients, it is important not only to remove such an excellent culture medium as blood but also to effect re-expansion of the lung and obliteration of the pleural sac as quickly as is consistent with safety and comfort—and this can be done only by air replacement. If infection does occur after air replacement

has been carried out there is at least a likelihood that the process will be localized so far as the pleura is concerned, and that the illness will thus be shortened. Re-expansion of an undamaged lung after air replacement is quite rapid, judging from recent experience, especially if it is helped by inspiratory breathing exercises. Patients are well in a month, and fit for duty in two to three months. Only those small effusions which do not reach above the dome of the diaphragm can be exempted from air replacement; they are in any case difficult to remove.

To the description of the technique of air replacement already given by Chandler I have little to add. Recently I have used simple syphonage through a large bore aspirating trocar and cannula attached to a length of rubber tubing. Air can be admitted through this cannula, or through a separate pneumothorax needle inserted through an upper intercostal space. With the former the air introduced is not measured, and the final pressures are left at atmospheric pressure of necessity; with the latter some re-expansion of the lung can be encouraged by limiting the amount of air introduced, and the final pressure can be left at any figure which is desired. This second technique is the one of choice for most patients, especially for tension hæmothorax. For the commoner tension hæmo-pneumothorax it is preferable to use two needles, for, although no air may then be introduced, the pressures can be watched for a short period at the end of aspiration, and if a rising pressure indicates a persistent valvular opening from the lung, the upper needle can be left in situ in connexion with an under-water drain.

Among the difficulties of air replacement a dry tap is often due to the choice of too low a site for aspiration, in turn due to the fact that the diaphragm on the affected side is, in these patients, usually situated at a high level. Another difficulty is that villous tags of fibrin may block any but large cannulæ. If a posterior site is chosen for aspiration, difficulty may be found owing to the end of the cannula coming into contact with the re-expanding lung as fluid is withdrawn; what has been an easy aspiration suddenly becomes one in which any further blood is withdrawn only with the greatest difficulty. This can be remedied by introducing air, when the lung collapses again away from the aspirating needle and blood once more begins to flow readily. Apart from these difficulties concerned with the state of affairs in the pleural sac, most of the failures are due to the choice of an aspirating needle or cannula which is too small in bore. It is essential to use one that is large enough, and this can be done without fear of incurring infection.

There are a few examples of simple hæmothorax with massive clotting, forming either a gelatinous mass or a carpet of fibrin and entangled corpuscles. Failure to aspirate a hæmothorax after using a proper technique should always arouse the suspicion that this state of affairs exists. A massive gelatinous clot gives a radiological picture which is in no way distinctive, and with a fibrin clot the appearance is likely to lead to its recognition only if gas is also present, and if a hæmatoma of the lung be excluded. A solid hæmothorax should be evacuated by open thoracotomy provided that the general condition of the patient permits, for it is a potent source of subsequent ill-health as it absorbs only with much difficulty.

Compound hæmothorax.—This term includes all those examples of traumatic hæmothorax which are accompanied by evidence of serious injury to the lung or chest wall, or by a retained foreign body. It is admittedly most difficult to gauge the extent of injury to the lung, especially with a large hæmothorax present, but it is important to try to do so, and to seek further means of improving the criteria upon which such injury should be judged. Perhaps the most important evidence is derived by inference from the type of missile, its size, probable velocity, and the position of the wounds which it has caused, and their size. The presence of comminuted ribs or of a leaking hæmothorax also gives support for an opinion that the lung has been damaged severely. Hæmoptysis, though important as an indication of bleeding from a large vessel if it is severe, is in practice of little help in most patients. Evidence of a bronchial fistula is valuable, and often also the direct radiological findings.

If it seems probable that a considerable laceration of the lung or hæmatoma is present then thoracotomy is the treatment of choice provided that it is done within about six hours from the time of injury, and provided also that shock and the effects of hæmorrhage have been controlled sufficiently well to make surgery judicious. The

advantages of surgical treatment are that it allows excision of the wounds, provides opportunity of emptying the pleural cavity thoroughly, and of arresting hæmorrhage, allows the removal of traumatized segments of lung, and also allows healthy lung to be inflated at the end of operation and the pleural cavity to be drained. Emergency surgery of this kind is restricted in its application by many factors, and it is in any event available only during a limited period of a few hours because of the risk subsequently that infection is already under way in the compound type of case for which it is desirable. But the results can be dramatic, and patients who otherwise would pass through many weeks or months of dangerous illness can be rapidly restored to health.

What has been said briefly concerning the influence of injury to the lung upon the choice of treatment in hæmothorax applies equally to cases with a retained foreign body, provided that this is single and accessible and that its size is no bar to the probable success of attempted removal. The incidence of subsequent infection, pleural or pulmonary, runs parallel with the incidence of retained foreign bodies; and, in view of the risk which infection brings, the early removal of retained missiles is likely now to establish a secure place in the treatment of such patients.

Infected hæmothorax.—The possibility of infection in a hæmothorax must be kept constantly in mind, for it may occur later, up to several weeks after injury. The classical features are not always found, and often the only certain means of diagnosis is the aspirating needle. If organisms are found in smears treatment should begin at once, for it is unwise to wait for confirmation from culture reports as the growth in the chest is at least as rapid as in media, and delay may mean disaster.

The correct treatment of an infected hæmothorax in its early stages is repeated aspiration, as it is for other forms of empyema. It is a mistake to insert a drainage tube until the infection has become localized. The proper re-expansion of the lung is a slow and difficult process in these patients, and if a tube is used too early there is risk not only of collapse of the lung due to admission of air, but also that loculation of the infection is made more likely and subsequent drainage more difficult. The result is that recovery is slow and hazardous.

The nutrition should be well maintained. These patients waste rapidly because of the severe toxæmia, and for this reason and also because of the difficulty of nursing and the fact that quite often they have been dragged to safety along the ground with the production of excoriations on the buttocks, they readily develop bedsores. Careful feeding and attention to the pressure points from the start can materially help in promoting recovery.

Surgeon Commander G. A. Mason, R.N.V.R.: Injuries to the parietes, lung, mediastinum, heart and abdominal viscera—when the diaphragm is torn—are among the causes of traumatic hæmothorax. External wounds and retained foreign bodies may or may not be associated with these injuries.

Unless a large vessel is injured, bleeding in cases of closed hæmothorax is apt to cease spontaneously by clotting and as the pressure in the pleural cavity attains equilibrium with that in the bleeding vessel. This mechanism functions earlier rather than later because of the severe degree of shock manifested by many of these cases, especially if intercostal nerves are damaged. Similarly, if air has entered the pleural cavity, the consequent collapse of the lung tends to check further bleeding from wounds in that organ.

Too much reliance should not be placed upon the pulse; in the early stages, a strong slow pulse may be the expression of a damaged autonomic nervous system rather than of a satisfactory circulation, and it may change for the worse very rapidly.

Clotting usually occurs over the diaphragm and the parietes, its distribution being determined posturally.

Spontaneous absorption of the blood is frequently accompanied by elevation of temperature and pulse-rate and often by slight icterus.

Exacerbation of the temperature may indicate further hæmorrhage, or the occurrence of infection; when it occurs, a new X-ray picture should be taken, a fresh sample of the pleural contents withdrawn for examination and another leucocyte count made.

Reactionary hæmorrhage of any magnitude calls for exploratory operation.

Infection of a hæmothorax may occur apart from organisms introduced at the time of the injury, as a consequence of ischæmic changes and necrosis occurring in the underlying

lung as a result of its contusion. The supervention of infection is evidenced by a rising leucocyte count, the presence of pathogenic organisms in the sample of effusion withdrawn and the general clinical picture. Confirmation by the bacteriologist is not awaited ; if the sample withdrawn is malodorous, infection is present.

If infection does not develop, the hæmothorax may be allowed to absorb spontaneously, or aspiration and air replacement may be employed. The latter is usually desirable as it shortens convalescence and facilitates adequate X-ray inspection of the thoracic contents. It is done according to preference from four to six days after the injury, but not earlier than the third lest further bleeding be precipitated, or later than ten days if there is no definite X-ray evidence of commencing absorption. Opinions vary on this, but this is my present practice.

Massive clotting may occur—this may either be absorbed or, becoming organized, may cause gross distortion within the hemithorax or give rise, eventually, to calcified masses therein. The question of evacuation by operation arises, but, personally, I prefer to reserve this for those cases in which there is the further complication of infection. The diagnosis of this may be a matter of some difficulty, especially if adequate material for examination cannot be obtained by aspiration. In that case, reliance must be placed on the general condition and on repeated leucocyte counts. If these are inconclusive and doubt remains, then an exploratory thoracotomy, evacuation of the clots and provision of syphon drainage are indicated. I have had no experience of the use of proteolytic ferments prior to attempts at removal of such clotted blood by aspiration.

Routine exploratory operation has been advocated for all penetrating wounds of the chest seen within the first twelve hours—as with similar wounds elsewhere. A major operation should not, however, be undertaken for small, non-sucking wounds, provided there is no progressive hæmorrhage and no suggestion of involvement of the abdominal viscera. These small wounds merely require excision and suture under local anæsthesia.

Evidence of continued or recurrent bleeding and the supervention of infection are, therefore, indications for exploratory operation. It is also indicated if there is evidence, from the nature of the injury or from the presence of peritonism, of abdomino-thoracic injury. Early operation is also called for when there are jagged wounds, or evidence, radiological or presumptive, of the presence of large foreign bodies or of bronchopleural fistulæ. This last complication may be recognized, sometimes, by the coughing of bloody froth in association with the signs of pneumothorax, and, if the latter is of the valvular variety, by severe distress due to the raised tension within the pleural cavity. This may require treating, as a preliminary emergency measure, by a Bülau drain introduced under local anæsthesia, after which, persistent bubbling of air to and fro through the syphon tube may be noticed.

Careful radiological estimation of the state of affairs within the chest before operation, and the way in which the films are exposed, are important. A standard antero-posterior film, with the patient sitting up, is necessary, and also a lateral view, in the prone position. If the upright position is contra-indicated, then both films may be taken in the horizontal position, with an additional antero-posterior film while the patient is lying on his side. Anæsthesia may be either local or general, but some means of obtaining differential pressure must be available.

Preparation for operation is by preliminary rest under morphia, during which a blood transfusion may be given if required, and harmful afferent stimuli from the affected segments controlled by intercostal blockage with A.B.A., proctocaine, or similar local anæsthesia. Oxygen may be administered with benefit by means of the B.L.B. mask, and the patient allowed to assume the position of greatest comfort. Any sucking wounds are, of course, occluded at the earliest moment by means of antiseptic pads.

Wound edges must be excised and any fragments removed. These wounds may, by suitable traction, permit of a complete exploration of the pleural cavity. If not, they must be closed and a deliberate thoracotomy carried out. This may be done through the standard postero-lateral thoracotomy incision along a middle intercostal space, with the patient lying on the opposite side, adequate exposure being obtained by means of expanding retractors. A similar, but not quite such a good exposure, may be obtained by an incision opening into the intercostal space anteriorly. In each instance, further exposure may be obtained by dividing the rib or cartilage above or below.

Blood is evacuated from the pleura by suction, or failing that, by means of absorbent pads or sponges, in which case unnecessary scrubbing of the pleura should be avoided.

Bleeding points are controlled by forceps and ligation, or by diathermy if the vessel is small and if a non-explosive anæsthetic is being used, or, if need be, by leaving tampons in position. The dual pulmonary circulation permits of ligature of main vessels of the lung without fear of necrosis. Lacerations in the lung are repaired, or, if a lobe is badly shattered, it is removed, and the diaphragm and pericardium inspected for tears which, if present, are opened up and injuries of the viscera beyond them are searched for and dealt with.

I never hesitate to leave a pack impregnated with B.I.P.P. in the chest for the control of hæmorrhage, stitching the skin over the end thereof, if possible. Sometimes, the desperate condition of the patient prohibits careful and deliberate toilet; we must then be content with controlling the bleeding by firm packing. Syphon drainage should always be used to prevent a sump accumulating in the lower part of the chest, even when a tampon is employed.

If the parietes cannot be closed *secundum artem* because of extreme damage or because of the general state, then tampons must be arranged to occlude the external wounds and to prevent a sucking pneumothorax. Elastoplast strips are placed across them, firmly supporting the chest wall. Some care is needed when working on the right side of the chest lest these packs press unduly against the great veins and interfere with the return of blood to the heart. Such packs will require changing, usually in from four to ten days; signs of infection call for early removal.

One of the principal objectives after any thoracic operation or injury is not only to restore maximum functional efficiency of the chest, but also to obtain complete occlusion of the pleural space if possible by re-expansion of the lung. Such occlusion may be facilitated by exercises of the MacMahon type, but in some instances, plastic procedures on the chest wall will be necessary for its attainment, because, if the lung cannot be persuaded to come out to the chest wall, this must be taken in towards the lung. In all cases, however, until there is positive evidence that such occlusion has occurred, drainage of the residual space must be maintained; premature abandonment of such a drainage tube may condemn the patient to a life of chronic invalidism.

Dr. J. L. Livingstone: In wards full of septic cases it is wise to do the gas replacement in a side room under full aseptic precautions to minimize the risk of infection. The operation should be done early—at twenty-four hours—before clotting or infection has taken place. When infection has occurred in a hæmothorax, I agree with Dr. Hoyle that treatment should be by repeated aspiration until a localized empyema has formed, which is then treated by rib-resection and drainage. Though air-tight drainage via an intercostal tube has all the theoretical advantages, yet in practice there are difficulties in preventing leakage of air and a total empyema.

Mr. Tudor Edwards said he did not propose to discuss the diagnosis nor to consider the group which Dr. Hoyle had called the "compound" group. Likewise, conditions such as when a large foreign body was retained and where a major operation was obviously indicated, appeared to be beyond the scope of the discussion.

This left two groups—hæmothorax from crushed chest, becoming more numerous owing to bomb casualties, and hæmothorax due to missiles which had passed through the chest or associated with the retention of one or more small shell fragments.

He was of opinion that, once the condition of shock had passed, the sooner the blood within the pleural cavity was removed the better.

There was no risk of the hæmorrhage, if arising from the lung, recurring, provided that the blood removed was replaced by air of the same quantity. This could be carried out with a pneumothorax apparatus, if available, through a second needle puncture or through the same two-way needle as that used for aspiration. In the latter case each two or three syringes of blood removed were followed by the introduction of a similar quantity of air.

Early aspiration had obvious advantages: (1) it removed the blood before clotting occurred; (2) it removed an excellent culture medium for organisms; (3) when the hæmorrhage was the result of damage to the vessels of the chest wall and was continuing, it could be diagnosed early by radiological examination or physical signs and before the general signs of hæmorrhage were present if gas replacement had been carried out early, as the increase in fluid within the pleura was obvious owing to the presence of the air there. Where air replacement had not been carried out bleeding might continue without alteration in the physical or radiological signs, as the lung gradually collapsed beneath

the fluid until general signs of internal hæmorrhage appeared ; (4) it prevented the late results of pleural fibrosis and chest contraction and the occasional occurrence of encysted collections in the pleura.

Those who had seen any large number of late chest cases from the 1914-18 war would recall that such collections were sometimes associated with a calcified wall to the encysted fluid which was found to consist largely of cholesterin crystals.

With regard to the objection which had been raised to repeated aspiration that it increased the risk of infection of the chest wall, it must be stated that such infection often resulted when air-tight intercostal drainage was adopted. In any case, the risk of infection of the chest wall could be overcome by a method suggested by the speaker many years ago. This consisted in an incision of the chest wall under local anæsthesia down to or even including resection of a portion of rib, but without opening the pleura. Aspiration was carried out through the intercostal space or rib bed and on its completion the incision was packed with flavine gauze. When further aspiration was required the pack was removed and the needle inserted as before. This had the advantage that the granulation tissue formed around the pack prevented the spread of infection in the chest wall and also permitted painless aspiration without the use of local anæsthesia.

Mr. Vernon Thompson : The immediate treatment of traumatic hæmothorax is essentially the immediate treatment of the injury to the chest and of the general condition of the patient. Some interesting points have arisen in the management of hæmothorax at the Chest Centre at our hospital. We have encountered very little difficulty in the actual aspiration ; in uninfected cases there has been no clotting and the lung has re-expanded completely after very few aspirations, the average number being three and the maximum being six. Every hæmothorax is accompanied sooner or later by a serous effusion, so that the fluid in the chest is not pure blood. This is easily shown by estimation of the hæmoglobin in the fluid. In a patient seen recently by Mr. Holmes Sellors six hours after the injury the hæmoglobin was 52%. In another patient aspirated two days after the injury the hæmoglobin was 42%. In the majority of our patients the hæmoglobin has been below 20%. The loss of protein resulting from hæmorrhage and effusion in infected cases may be serious. Two of our patients developed œdema of the extremities and we consider it important to make good this loss by blood transfusion or by infusion of plasma.

The technique of aspiration is very simple but it is unfortunate that it is not more generally understood. The importance of using a two-way tap or a syringe with a valvular mechanism is not generally recognized. The disadvantages of allowing air to enter the pleural space by disconnecting the syringe from the needle need to be impressed. We never know whether a hæmothorax is infected or not until it has been aspirated, and although the admission of air is no great disadvantage in uninfected cases, in infected cases it may by producing a complete empyema seriously delay recovery. Aspiration of blood with air replacement has been very generally advocated at this meeting ; but we regard air replacement as a purely emergency measure ; it is done to collapse the lung and prevent further hæmorrhage from the lung itself. Once the hæmorrhage has ceased it is our aim to obtain re-expansion of the lung as soon as possible : and for this purpose it is necessary to remove the air as soon as it is considered safe. As a general principle it is unwise to introduce air into an infected pleural space before adhesions have developed. It merely produces a total empyema, when by aspirations or by closed intercostal drainage without admitting air the empyema space can be limited to a localized posterior pocket, which heals readily with adequate drainage.

It is easy to obtain lung re-expansion in the early stages ; but if efforts to this end are delayed, clotting, pleural thickening, and other complications make restoration of function increasingly difficult.

Finally I would like to stress the great value of instruction and exercises in controlled breathing in the restoration of complete function. It is our practice to give these exercises to all patients with chest injuries at an early stage. The steady improvement in chest movement and in vital capacity that results is a large factor in restoring them to normal health.

Mr. R. C. Brock : The differentiation of hæmothorax into simple and compound types suggested by Dr. Hoyle is worthy of emphasis although it is probable that a better term than compound might be found. The suggested analogy with fractures is borne out by the grave risk of serious, and possibly fatal, infection in the compound or surgical

type if not dealt with by prompt surgery. In the simple type aspiration is usually satisfactory except where clotting has occurred. Such cases may have to be treated by open evacuation of the clot. Aspiration should be done early although it is usually neither convenient nor kind to submit the patient to it until he has had an opportunity to rest after his trying experience; this usually means 18 to 24 hours after injury.

Although in the compound variety there is usually a major surgical wound present which demands operation, and the hæmothorax should therefore be dealt with incidentally at the same time, the presence of the hæmothorax is put so prominently in the clinical picture that it is judged to be a leading feature instead of a subsidiary one. The presence of a retained foreign body, particularly a large bomb or shell fragment which by inference has caused more than trivial damage to the lung, is a probable indication for operation; if evidence of a fistula is present, operation is needed. With regard to damage to the chest wall, a fractured comminuted rib suggests the need for surgery and damage to a costal cartilage should make surgery imperative. In all of the cases which we have had at our Centre in which cartilage was damaged by the missile an obstinate and prolonged infection has followed.

A wound that is big enough to cause sucking will not do so if there is a large hæmothorax, but instead blood pours out on movement, coughing or with respiration—so-called "leaking hæmothorax". This condition demands operation and yet it is often treated conservatively; I think because the rush of blood is so frightening that cool judgment is impaired.

These cases of compound or surgical hæmothorax need bold surgery urgently and if so treated within the first few hours make a rapid, complete recovery. This is in contrast with the patient who has a contaminated wound leading down to an unevacuated large hæmothorax with a retained foreign body.

When infection has occurred in a big clotted hæmothorax the position is very difficult. Aspiration fails, intercostal drainage fails, and rib resection unfortunately gives a total empyema. The best treatment in this as in compound cases is avoidance; it should not be allowed to occur.

Mr. O. S. Tubbs: Previous speakers have stressed that the only certain means of demonstrating that infection has complicated a hæmothorax is by pathological examination of a sample of fluid withdrawn by paracentesis. But there are a few instances in which demonstration of infection even by this means may be difficult: this applies to those cases in which clotting has occurred in the hæmothorax with the formation of many loculi and the subsequent infection of some but not all of these loculi. Two such cases from France were admitted to the Thoracic Unit at a hospital after five days had elapsed from the time of their being wounded. Both patients belonged to the "compound" group described by Dr. Hoyle. Their wounds, which were almost identical, were caused by a rifle bullet and a tracer bullet respectively, which had entered the chest wall just medial to the angle of the scapula and had coursed in the chest wall up to the supraclavicular fossa, fracturing the posterior segments of six ribs. Both had hæmothoraces of moderate size. Both had high fever and were obviously toxic on admission but in each case samples of blood-stained fluid were withdrawn from various sites on numerous occasions and again and again proved sterile on aerobic and anaerobic culture. After three or four weeks during which the patients were exceedingly ill, infected fluid was finally obtained. When drainage by rib resection was carried out, it was found that the pleural space was divided up by fibrin into numerous loculi, some of which contained thick pus, others thin pus and yet others apparently uninfected fluid. It would seem justifiable to assume infection in such cases with obvious toxæmia, high fever and a polymorphonucleosis.

Reference has been made to the possible value of chemotherapy as a measure to prevent infection complicating hæmothorax. We had a case of a girl of 14 with a perforating thoraco-abdominal wound of the right lower chest which caused a large tear in the liver. A piece of liver removed at operation yielded *Cl. welchii* whose toxin-producing properties were shown experimentally to be high. The diaphragm and chest had been sutured without drainage. Intensive chemotherapy did not prevent gas infection occurring in the pleural cavity but, although gas formation was seen below the diaphragm early in the post-operative period, it disappeared without the provision of drainage and the child did well after drainage of the empyema. This suggests that the sulphanilamide modified but did not abort the infection.

Section of Surgery

President—J. B. HUNTER, M.C., M.Ch.

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DISCUSSION ON CHEST INJURIES

Mr. C. Price Thomas: These observations are the result of a study of the cases admitted to a Chest Unit, where it is the custom for the whole group, two physicians and three surgeons, to make a weekly round and enter into free discussion on all cases.

Chest wounds as a group are second only to abdominal wounds as a cause of fatality in war. Hoche, reviewing 11 million wounded of English, French, American and German nationality, quotes the following figures:—

TABLE I.—DISTRIBUTION OF WOUNDS.

	Per cent.
Limbs	68
Head, face and neck	15
Spine and cord	4
Pelvis	3
Thorax	6
Abdomen	4

Mortality in Above Series.

Total	8
Abdomen	68
Thorax	56

In reviewing the cause of death among 12,350 killed, the distribution of the wounds was as follows:—

	Per cent.
Head	47
Thorax	20
Abdomen and pelvis	11·8
Limbs	9·9

It will be seen from these figures that, despite the low total incidence of chest wounds, there is an extremely high mortality rate, and also that among those who die before there is any question of medical aid, chest wounds rank high in the list. Chest wounds are heir to all the damaging effects of wounds in other regions, shock, hæmorrhage and sepsis. In addition there are other factors to which this high immediate and late mortality can be attributed.

In the main these factors are dependent on the interference with the patient's cardio-respiratory reserve.

The conditions producing this interference are :—

(1) *The presence of either air or blood in the pleural cavity* under sufficient pressure to encroach not only on the homolateral but also on the contralateral lung, as a result of the ensuing mediastinal displacement, this displacement at the same time producing severe cardiac disability, chiefly by inefficient filling as a result of distortion of the superior and inferior vena cavæ.

(2) *Open pneumothorax.*—The ill-effects of this condition briefly stated are : (*a*) Lung collapse on the affected side ; (*b*) *Pendelluft*—that is the pendulum swing of air during respiration from the expanded to the collapsed lung and vice versa ; (*c*) mediastinal flutter, the paradoxical swing of the mediastinum during inspiration and expiration with the stimulation of the contained cardiac and pulmonary plexus ; (*d*) the loss of aspiration on the great veins leading to deficient diastolic filling of the heart, in its turn leading to deficient cardiac output.

All these factors if allowed to remain unchecked in a case where, either the deficiency in the chest wall is large, or even when small in a patient with a low vital capacity, will lead to a fatal termination by anoxæmia.

(3) *Cardiac tamponade.*—This results from fluid in the pericardial sac constricting the heart and preventing efficient diastolic filling. In these cases the fluid accumulates rapidly before the pericardium has time to stretch, and consequently a relatively small quantity of fluid is enough to produce a fatal outcome.

All these factors operate more seriously in the old than the young. The young person's vital capacity has not been impaired by pulmonary disease or factors limiting efficient expansion of the thoracic cage, such as calcification of costal cartilages or osteo-arthritis of the costo-vertebral articulations. Their cardiovascular systems also have not yet felt the strain of life.

This point was well illustrated by the contrast between the A 1 young soldiers we got from Dunkirk and some of our air-raid casualties, although it should be noted that present air-raid casualties are, in fact, battlefield casualties—a group not necessarily A 1 and covering the whole age range.

The factors discussed above, together with those common to all wounds, shock and hæmorrhage, and the question of morbidity, both early and late, are the considerations when called upon to treat any of these cases.

In combating shock it is established that the rapid replacement as early as possible of the circulating colloids will cut short the period of peripheral anoxæmia, the factor leading to damage of the capillary bed. In this way we may hope to reduce the number of disappointing cases in whom after plasma and blood have been given by the drip method, the blood-pressure has risen satisfactorily to 100-110 mm.Hg, only to fall again when the plasma supply has stopped, probably as a result of leakage through the capillary bed. 90% oxygen through a B.L.B. mask should be given from the outset, to assist in overcoming the peripheral anoxæmia.

Hæmorrhage presents the same problem here as in other parts of the body, except that here, as in the abdomen, considerable blood loss may occur without overt evidence.

Patients who die during the first forty-eight hours, die as a direct result of factors already mentioned. Those who survive this period only to succumb later do so as a result of sepsis, most commonly pleural or pulmonary, or a combination of both. Sepsis results from the presence of a retained foreign body, badly lacerated and dead tissue, and conditions which are favourable to the further growth of the infecting organisms. The pleural cavity with a hæmothorax provides an ideal culture chamber for such a process, and our aim, where practicable, should be the removal not only of the nidus, but also of the culture medium, the hæmothorax, and to induce expansion of the lung at as early a stage as possible to obliterate the pleural space. By this we hope to lessen not only the mortality in these cases, but also the period of convalescence, and perhaps even to obviate the chronic invalidism of later years resulting from chronic empyema, lung abscess, and bronchiectasis. One other cause of late morbidity is the inefficiently treated hæmothorax which, when left, organizes and forms a mass of fibrous tissue which may later become calcified, thus preventing effective expansion of the lung. This disability only becomes obvious in later years when other factors lowering the vital capacity become operative.

The surgeon must decide in each individual case between the necessity for intervention, the immediate risk, and the longer view of possible or probable morbidity.

An accurate history of circumstances at the time of wounding should be taken, viz.: the wounding agent, distance from the bomb explosion in view of possible blast, the position of the patient when hit, as a guide to the direction of the missile, the occurrence of hæmoptysis, loss of consciousness, or faintness, pain, &c. Complete examination of the patient is necessary, and where the wounds suggest a thoraco-abdominal injury, abdominal and urinary examination are important. The degree of severity of wounds when multiple is assessed, and attention given to the most severe, with two teams working simultaneously on the patient, if possible.

Physical examination of the chest reveals the character of the wounds, any damage to ribs and the presence of air or blood in the chest. Direction of the missile if ascertainable may give valuable presumptive evidence of the track and structures damaged. Both antero-posterior and lateral X-ray films are necessary to localize opaque foreign bodies, to reveal either a hæmo- or pneumo-thorax and injuries to the bony cage. If possible one antero-posterior film should be a penetrating one, as it is quite easy to miss a foreign body completely when it is overlaid by the heart and vertebral or diaphragmatic shadows, or by a hæmothorax.

Films in early cases are nearly always taken in the recumbent position and it is well to remember that a considerable hæmothorax under these conditions may show only as a slight ground-glassing of the whole lung field, the typical " black-out " effect only appearing after the patient has been in the Fowler position a little time. Hæmopneumothorax will show a fluid level always in one or other film. Occasionally, however, films of a hæmothorax give an odd appearance resembling coils of gut which simulate a diaphragmatic hernia and give rise to diagnostic difficulties. X-ray photographs at frequent intervals are of paramount importance during the post-operative management.

Experience has repeatedly shown that operation, when indicated, and the patient's condition will allow, should be done within the six-hour interval immediately following the infliction of the wound if the best results are to be obtained. Circumstances over which there is no control may, however, make this impossible, as with the troops evacuated from Dunkirk. In such cases, primary operation is not feasible, and, speaking generally, if it is not feasible within the first six hours, operation as a primary intervention should be withheld except in special circumstances.

Definite indications for operative intervention during the six-hour interval, if the patient's condition will permit, are: (1) Wounds producing an open pneumothorax, more graphically called sucking wounds; (2) hæmorrhage which is overt and progressing; (3) hæmothorax with a retained foreign body; (4) hæmothorax where there is reason to suspect, from the direction of the injury, the position of the foreign body, or other radiological or clinical evidence, that the diaphragm, heart or pericardium has been injured.

The cases which will not need operative intervention are: (1) Through-and-through wounds without hæmothorax or hæmoptysis; (2) through-and-through wounds where entry wounds do not constitute sucking wounds, even in the presence of a hæmothorax. But there will be many borderline cases which will be dealt with at the discretion of the individual surgeon.

Tension pneumothorax and hæmothorax were fully discussed at a meeting of the Section of Medicine (v. *Proceedings*, 34, p. 73).

There are certain prerequisites for successful intervention in these cases; one, as important as the surgeon himself, an anæsthetist who is skilled in the management of thoracic cases. It is perhaps only those of us who constantly practise thoracic surgery who fully appreciate how much a successful outcome depends on the skilful anæsthetist in a difficult case. Good light is essential, not only overhead, but an efficient portable light so that the whole thoracic cavity can be inspected. An efficient rib spreader is also necessary to allow freedom of movement in the pleural cavity. These are essential, and although a complete set of thoracic instruments are a great asset they are far from being necessary. Operation is usually done with the patient lying on his side, with a sand-bag under the axilla, and we use in our mobile team a chest rest, divised by my colleague, Mr. R. C. Brock, which is very valuable and will fit on any table.

The essentials of the operation are: Complete surgical revision of both entry and exit

wounds. It is well to note that there may be an entry and apparent exit wound with the foreign body still inside the chest, the exit wound having been made by rib fragments blown through the chest wall. The revision should be carried down to the pleura, and fractured ribs should be resected to leave clean sound surfaces, all loose bony fragments being removed. We have been constantly faced with cases in which excision has been done and this important part omitted. If one of the wounds is situated at a place convenient for thoracotomy this should be enlarged and the chest entered at this site, but the temptation to explore through an ill-placed incision should be avoided at all costs. An intercostal incision is preferable, but there is no objection to entering through the bed of a resected rib, as the gap can be closed with pericostal sutures. In young patients with flexible chest walls a simple intercostal incision is all that is necessary, as the space can be spread sufficiently with a good rib spreader. In older people it is wiser to resect a small segment of the rib above the space at its posterior end and if necessary doubly ligate and divide the intercostal vessels and nerve. A thoracotomy opening 6-7 in. long is usually ample, but there should be no hesitation in enlarging it if this proves to be insufficient. To prevent wound contamination the whole thickness of the wound should be covered with warm flavine packs which are kept efficiently in place by the double rib spreader. The chest is now emptied of blood and clots, preferably with a sucker which prevents the trauma to the pleura associated with swabbing. The lung, mediastinum, pericardium, diaphragm and chest wall are then inspected.

Lung.—This is the commonest site in which to find the retained foreign body. It can usually be easily palpated, but in some cases when there is a large hæmatoma in the lung it may not be easy. The degree of lung laceration is assessed and the site of the foreign body. With larger ragged foreign bodies the degree of laceration may be severe and if so it is probably wiser to resect the lobe if the patient's condition will permit. Simple removal of the foreign body in these cases inevitably leads to a prolonged period of chronic sepsis and illness. If the foreign body is situated in a fringe of the lung, wedge resection of the lung including the track of the foreign body gives the best results. In a large number of cases, however, simple removal of the foreign body will be all that is possible.

While removing foreign bodies close to the hilum great discretion should be used and unless the surgeon is prepared to face a lobar resection or difficult ligation they are best left alone. The presence of a lung hæmatoma does not call for resection, but most certainly calls for a removal of a foreign body. These cases, even without a retained fragment, may suppurate, and they most certainly will if one is retained. In certain cases the lung may be adherent to the chest wall at the site of injury. This type will only come up for operative intervention when the foreign body is large and there is a good deal of chest wall destruction. Adhesion of the lung will be suspected in the absence of a hæmo- or pneumo-thorax, and in these cases the pulmonary condition will be dealt with during surgical revision of the wound, which includes the removal not only of the foreign body, but also of the bone fragments, which are apt to be overlooked. The wound is then packed as in dealing with a lung abscess and not sewn up.

Mediastinum.—Unless the foreign body presents itself easily it is best left alone. These foreign bodies rarely give trouble in later years.

Pericardium.—Blood in the pericardium, or a wound in the pericardium, needs investigation. The pericardium should be opened, in front of or behind the phrenic nerve, or in the line of the opening, the edges of which are excised. The sac is aspirated clean, and the heart chambers examined. In the case of cardiac wounds, a free flow of blood will continue after the sac is opened, and this can be controlled by one of the various manœuvres, while the wound is sutured. The pericardial wound should then be closed.

Diaphragm.—A wound of the diaphragm should be enlarged in a radial direction and the subdiaphragmatic area examined. In cases where no clinical evidence of abdominal damage exists, there is no need to make an extensive examination. Where abdominal injury is strongly suspected a wider incision is indicated and it may be necessary to continue the thoracotomy incision through the costal margin, or do a separate laparotomy. In all cases, however small the incision, the diaphragmatic deficiency must be closed, as even from the smallest puncture a sizable diaphragmatic hernia may result later.

Chest wall.—In cases where the exit wound has not been caused by the foreign body itself but rather the rib fragments, the foreign body will often be found in another

pocket in the chest wall and should be removed when accessible. No elaborate operative removal should be embarked upon however, as if it has passed outside the pleura it is probable that it will cause no further trouble. During all this intrapleural manipulation an anæsthetist skilled in the management of these cases will lessen the call on the patient's cardio-respiratory reserve, and also make the manipulation easier for the surgeon by rhythmically ventilating him under controlled respiration. All the intrapleural manipulations being finished, the pleural cavity is flushed with a warm weak acriflavine solution if no big fistula is present, and sucked dry, and the chest wall is closed in layers, with pericostal sutures to approximate the ribs. The practice of plugging wounds of the chest wall cannot be too strongly condemned; it inevitably leads to sepsis and infection of the pleural cavity. If the pleura is closed and the wound sutured, infection of the chest wall wound a few days later does not necessarily mean a pleural infection. If an intercostal trocar is not available a tube is introduced through an intercostal space, by pushing a pair of Spencer-Wells' forceps through a small skin incision between the ribs, before the chest is closed and a Malacot catheter is pulled through from within outwards. If a Malacot catheter gauge 24-26 F. is not available, a straight firm tube of the same bore will suffice, being left projecting into the chest 1½ in. If a trocar is available it is preferably inserted after the chest is closed, as it ensures that the track through the muscles and intercostal space will be in the same line.

The dressings are fixed with strapping which is carried just over the mid-line anteriorly and posteriorly. This manœuvre not only supports the operated side, but also allows a free expansion of the sound hemithorax. On the patient's return to bed, the intercostal catheter is attached to an empyema bottle, which provides water-sealed drainage. The management of this type of drainage should be clearly explained to the nursing staff, and simple and safe measures for keeping free drainage demonstrated. During the immediate post-operative period the patient is nursed lying down, but as soon as the general condition will allow, generally in a few hours, he is gradually raised to the Fowler position. In uncomplicated cases, the intercostal tube should be removed in from forty-eight to seventy-two hours. The use of oxygen given by a B.L.B. mask is as important after as before the operation.

The post-operative course demands unremitting care and attention, with close radiological and clinical control. Fluid collections will need aspiration. The occurrence of sepsis and its location will need recognition, whether it be pulmonary, pleural or in the chest wall, and the appropriate treatment carried out. In my opinion those cases which have undergone these primary operations outside a chest centre, should be transferred to such a centre during the ensuing two to four days, so that the post-operative course can be conducted where the whole staff, not only medical, but also nursing and porter, are experienced in their management. This also applies to those patients in whom operative intervention was deemed either undesirable or unnecessary.

Dr. J. L. Livingstone: I have not gone out with the mobile surgical team and therefore have not had the experience of the other openers in dealing with cases immediately after injury. My remarks are based on an experience of some 200 cases of chest injury, from the point of view of a physician at a base hospital.

Clinical diagnosis.—Physical signs are difficult to elicit on account of shock, surgical emphysema, dressings, and other injuries, while the patient is often unable to co-operate. The basic physical signs are therefore all the more important, viz. cyanosis, movements of the chest, the colour of the mucous membranes, the sound of the cough and the character of the sputum, and one should note any displacement of the apex-beat or trachea, signs of tension pneumothorax and the level of obvious dullness. A skin-pencil is useful in marking some of these features.

Severe internal injury may be present without any external sign and the size of the entry-wound is no guide in this respect: one should try to visualize the course of the missile, when possible. Wounds of the lower chest may be associated, at the time or later, with sudden onset of abdominal rigidity, exactly simulating acute peritonitis: a laparotomy may be necessary, but this point should be remembered in such cases.

An essential in diagnosis is the exploring needle which should be of good size, No. 14 or 13, B.W.G., and it is useful to have a two-way tap between the needle and record syringe. In selecting an intercostal space, allowance should be made for a high diaphragm, so

commonly present. Specimens of fluid obtained should be put in two sterile tubes, one to be retained in the ward for naked-eye inspection and comparison with future specimens, and the other to be sent for culture and for a stained smear, which may give the immediate diagnosis of infection. Stale blood in the pleura may grow bacteria just as well as the culture medium in the laboratory; on occasions the direct smear has shown *Cl. welchii*, which might not have been grown unless anaerobic culture was done; in short, the smear is a valuable procedure. If offensive smelling fluid is withdrawn it is certainly infected, and anaerobic culture is called for.

In addition to proving the presence of fluid, the needle may reveal blood-clot, thickened pleura, bile-stained fluid, particles of liver, &c. When infection is present, I advise caution in indiscriminate needling, as at times, meningitic reaction or local spread of infection may occur; clinical and radiological signs should localize the suspected collection of fluid before the needle is inserted.

Difficulties in radiological diagnosis.—Mr. Price Thomas has emphasized the extreme value of radiology in chest injuries. An additional point in technique is to give the patient a teaspoonful of bicarbonate of soda in water just before taking the films, in order to show up the left diaphragm with a large air bubble.

The interpretation of the films is sometimes difficult: (1) A considerable quantity of fluid may be present, particularly at the left base and in the supine position, with but slight opacity in the film: fluid, encysted between the diaphragm and base of the lung, does not give the usual sloping opacity in the lateral part of the thorax and may be incorrectly interpreted as consolidation; (2) collapse of a lower lobe, especially on the left side, is easily overlooked, even with a penetrated film; (3) metallic foreign bodies may be quite invisible unless a penetrated film is taken, and may be wrongly diagnosed as being intrathoracic if the lateral view is omitted. Fragments of glass are difficult to demonstrate; (4) blood-clot may simulate bowel shadows, suggesting a ruptured diaphragm.

Treatment

(1) *Diet.*—A number of men had been starved for three to five days before admission because they had coughed up blood; this is possibly because of statements in First-Aid Manuals, and indeed in the R.A.M.C. Training Handbook, 1935, that ice or sips of water only, should be given. These patients, even when pyrexial, are hungry and require a full and varied diet; when suppuration is present it is remarkable how quickly they lose weight. The ordinary hospital diet is usually inadequate in vitamins (particularly B and C), which should be supplied as a routine in the form of cod-liver oil and malt, together with one of the proprietary multiple vitamin tablets. Stout or ale seem to improve appetite and have an undoubted psychological effect. As anæmia from blood loss or sepsis is so common, iron should be given also as a routine.

(2) *Oxygen.*—When administered in high concentration, oxygen is most valuable for shock as well as for anoxæmia; the B.L.B. mask seems by far the most efficient method of administration but treatment is expensive. The 100 cu. ft. cylinders with reducing valve and flow-meter are required and the nursing staff needs instruction to attain satisfactory results.

(3) *Blood derivatives.*—In addition to the *rapid* transfusion of *large* amounts of blood or plasma for shock and hæmorrhage, smaller quantities of blood at the usual rate are valuable in cases of anæmia and debility from prolonged sepsis. I have been impressed with the suspension of washed red cells in 5% glucose for anæmia, as reactions seem uncommon and the concentrated cells raise the patient's hæmoglobin proportionately.

(4) *Sulphonamides.*—We have used sulphapyridine principally, both for prophylaxis and treatment, in view of the possibility of pneumococcal infection. Apart from vomiting, there have been few toxic reactions but we have found it necessary to have a uniform scheme of dosage and have the daily dose noted on the temperature chart. With a sudden rush of cases, as during the Dunkirk evacuation, it was easy to overlook the fact that excessive amounts were being given. It is wise to withhold the drug until the effect of adequate drainage of pus has been seen. In more than one case of "meningismus", the drug has prevented the onset of definite meningitis, in my opinion.

(5) *Nursing.*—In chest injuries skilled nursing is particularly important as complications may be frequent and sudden. The gravity of the chest condition or the presence of other wounds, make it easy to overlook bedsores; patients, both military and civilian, have often been dragged along the ground, with excoriation of the sacral area, before being put on a stretcher. Drainage tubes in the chest, entailing a sitting posture, are a further factor and the nursing staff should be warned on this point. For the same reason, postural deformities, particularly kyphosis and flexion of the knees, are common and patients should be encouraged to make active movements of the spine and limbs. Patients should be got out of bed as soon as possible, and so long as there is no toxæmia the fact that there is a drainage tube in the chest need not keep the patient in bed. This activity is good for morale and aids re-expansion of the lung. It must be stressed that patients with chronic sepsis, in hospital for many months, need encouragement and entertainment; occupational therapy is useful.

(6) *Physiotherapy.*—Special breathing exercises to promote expansion of the lung and proper diaphragmatic breathing are most necessary, and masseuses with special training are required. Exercises should be started early, but with wounds of the lung it is wise to wait for a week, in case of provoking hæmorrhage or spontaneous pneumothorax. Other exercises to prevent deformities of the chest and spine are given. Infra-red rays for chronic wounds and diathermy for intrathoracic sepsis have their place, while general ultra-violet light baths seem to have a tonic effect.

Complications

Complications are frequent and may be easily overlooked; close clinical observation is required, checked by radiograms from time to time. *Local* complications included: Collapse of a lung or lobe, with or without infection; spontaneous pneumothorax; bronchial fistula; hæmorrhage; infection of a previously sterile hæmothorax; lung abscess and pneumonitis; simple or infected effusions of the sound side; subphrenic abscess and pericarditis, infected or "sympathetic". Typical pneumonia was not seen, though cases of infection in collapsed lobes might be easily mistaken for this. *General* complications were: Acute dilatation of the stomach (6 cases); metastatic abscess in hip and brain; meningismus; thromboses; œdema and nephritis.

Tension Pneumothorax

In the typical case, diagnosis is easy on account of the textbook symptoms and signs; in less obvious types, however, the diagnosis may depend on sudden dyspnœa and the insertion of a needle to take the pleural pressure. The first-aid treatment is to insert a fine needle into the upper chest, through a piece of sterile tubing strapped to the skin, with tubing connecting the needle to an under-water seal in a bottle on the floor. It is preferable, however, to use a pneumothorax apparatus and after taking a preliminary reading of the pressure, to withdraw 600 to 1,200 c.c. of air and repeat the reading. If the pressure is negative and remains steady for ten minutes, the needle should be withdrawn; if the pressure rapidly falls or becomes positive, a valvular bronchial fistula is present and the needle should be attached to an under-water seal as before. The needle should be withdrawn eventually when air ceases to bubble off in the bottle, even after the patient blows out his cheeks.

Hæmothorax

Dr. Clifford Hoyle has pointed out that a hæmothorax or hæmo-pneumothorax might be an incident in any severe thoracic injury. When, however, the hæmothorax was the predominant clinical feature, he subdivided it into two headings: (*a*) "*Simple*" hæmothorax, in which there was no evidence of gross damage to the chest wall, lung or other viscera and in which there was no foreign body in the chest; (*b*) "*Compound*" hæmothorax, in which such damage or a foreign body was present. Both "simple" and "compound" hæmothorax might or might not be infected, but experience in the last war showed that the majority of cases in which infection took place, were associated with a foreign body. Of 115 cases of hæmothorax seen recently, 30% were infected.

With these points in mind, even though experience has proved that in many cases the

hæmothorax is absorbed completely without active treatment, I advise aspiration with gas-replacement in all but the minimal cases, for the following reasons :—

(1) *Diagnosis.*—Until the hæmothorax has been removed and further radiograms taken, it is impossible to be sure that the condition is not " compound "; if the lung is still further collapsed by proper gas-replacement, subsequent hæmorrhage probably comes from the chest wall ; surgical arrest of such bleeding would then seem the obvious treatment.

(2) *Prevention of infection.*—If the condition be " compound " with a retained foreign body, infection is likely to occur and removal of stale blood reduces this risk ; infection is less likely in " simple " hæmothorax but the same argument applies. If clotting has occurred—and the factors producing this seem to be unknown, though it is common with infection—the mass of clot acts as a nidus for bacteria. This clot is easily removed before it becomes organized by thoracoscopic aspiration, or by a small thoracotomy.

(3) *Subsequent return of function.*—After removal of the blood expansion of the lung is rapid and the patient may be fit to leave hospital in three to four weeks, instead of in as many months where natural absorption alone takes place. If clotting has occurred, organization of this is a slow process and often results in gross thickening of the pleura, fixation of the diaphragm, and subsequent flattening and immobility of that side of the chest. Many cases seen after the last war suffered severe disability from this cause. If sepsis takes place, the damage to the function of the chest is even more marked.

Treatment

I advise gas-replacement of the blood, performed carefully and under aseptic precautions, as soon as possible after the shock has been treated ; in practice, this usually means after twenty-four to forty-eight hours when X-ray films have been taken. By replacing with air, one is able to empty the thorax of blood without materially altering the collapse of the lung : attempts at forced aspiration without gas-replacement may be dangerous, causing, besides pain and cough, hæmorrhage or pulmonary œdema. It is also impossible to remove more than a proportion of the blood, whereas by allowing air to run in the high negative pressure is avoided and the blood is easily removed.

If, however, there is any doubt whether the hæmothorax is infected, gas-replacement should be avoided ; the fluid should be removed by repeated aspirations of small quantities until thick pus is obtained, when rib-resection and drainage of the localized empyema may safely be done. The aspiration should be done through an incision down to the intercostal muscles, kept open by a vaseline gauze pack. On theoretical grounds an air-tight intercostal tube, with syphon or continuous suction drainage, is the best treatment ; our experience has been that air does leak into the pleura causing a total empyema, and that pocketing of pus is common during subsequent re-expansion of the lung.

The technique of gas-replacement is well known and an excellent description has been given recently by Edwards and Morriston Davies in the *Lancet* [1]. A practical point is that the lumen of the nozzle of the 20 c.c. record syringe is too narrow to be satisfactory and I use a Dieulafoy aspirator. In hæmothorax a considerable exudation of fluid takes place during the first few days, presumably owing to the irritation of the pleura by the blood ; the pleural cavity should be kept as dry as possible by aspiration as required during the week following the gas-replacement ; a radiogram at this time may show clot or fibrin masses, which should be removed.

Blast Injuries of the Lung

I have had little practical experience of this type of injury but it is of considerable interest at the moment and I am mentioning the subject to promote discussion. In the few cases observed, it has been difficult to distinguish between the effects of blast alone and other factors such as blows on the chest wall, compression by heavy weights and inhalation of blood or dust. It is difficult to get an accurate history from the patient on these points.

In some half-dozen cases, blast was thought to be the main factor, but this is open to doubt. The diagnosis was made on the radiological appearances ; the multiple peripheral shadows, described by Zuckerman [2] in his animal experiments, were seen in two

infants but were not obvious in the adults, in whom a single diffuse opacity was seen in the hilum or in the posterior part of the right lower lobe. These shadows disappeared in a few days, and, in part at least, must have been caused by collapse. The clinical features were tachycardia, slight loose cough and occasional stained sputum, all of short duration. Physical examination revealed little during the first twenty-four hours, but subsequently fine crepitations and impaired air-entry with distant bronchial breath sounds were noted for a day or two.

REFERENCES

[1] EDWARDS, F. R., and DAVIES, H. MORRISTON, *Lancet,* 1940 (ii), 673.
[2] ZUCKERMAN, S., *ibid.,* 1940 (ii), 219.

Mr. N. R. Barrett : I propose to confine my remarks to wounds of the chest wall.

Excision of wounds.—All wounds, except those which are small and uncomplicated, should be excised if the patient is seen within a few hours of injury. It is unfortunately common to see cases in which the operation has been attempted through a tiny incision and the skin closed over infected tissues.

Most surgeons who have recently written about suture of wounds after early excision are agreed that it is only justifiable to close a wound in very exceptional circumstances. These circumstances include a mature experience in the selection of cases, perfect technique, and good facilities for the work. In the case of the chest wall the same advice holds good, with this exception that, in operating upon sucking wounds *which have been excised,* the surgeon must close the wound. In so doing he takes the possible risk of sepsis in order to avoid the certain danger of an open pneumothorax. If it has not been possible to do a thorough excision, suture of a sucking wound is not justifiable ; it should be covered with a large pad and made airtight in this way. Packs are often put into wounds of the chest wall but they encourage sepsis and hinder drainage.

The most difficult wounds to excise thoroughly are those in which a missile has penetrated the scapula and damaged the muscles and ribs beneath it. The superficial part of the track can be cut out, but to expose the subscapular muscles and ribs it may be necessary to make a separate incision, like the upper half of that used for thoracoplasty, and to lift the scapula off the chest wall.

It is important to distinguish between the wound itself and an incision made to explore the thorax at the site of election, because, if adequate precautions have been taken to protect the skin and muscles, *this incision can be closed* and will heal by first intention.

Types of Wound

There are two main groups. The first involve the superficial tissues and are straightforward, because their effects are limited to the chest wall ; the second include fractures of the ribs and open pneumothorax, and are dangerous if the normal functions of the heart and lungs are disturbed.

Superficial wounds.—Wounds of the muscles and superficial tissues are generally easy to handle ; large parts of the muscles of the pectoral girdle can be removed without loss of movement of the arm, and infections respond well to treatment.

The most serious injuries are those which involve the muscles of the back and shoulder. The reasons for this are that the scapula is contained in the deep muscle layer and is often fractured by crushes and penetrating wounds ; and that the muscle groups are separated from each other, and from the chest wall, by planes of fascia and areolar tissue in which infection, or blood, can travel a long way before coming to the surface. Deep suppuration in these fascial planes is difficult to diagnose because the classical physical signs of infection are hidden. The most important indications are pain in the lower part of the chest wall, and œdema in the loin.

Infections in the chest wall are not always directly connected with wounds, but occur around drainage tubes blocked by pus or granulation, or along the track of a needle after the pleura has been aspirated. The virulent types are those which accompany streptococcal and mixed infections of the pleural cavity, and spreading gangrene of the

skin. The former should be treated by incision, drainage and chemotherapy, and the latter by excision of the gangrenous area. It is fortunate that "gas gangrene" is not nearly as common in the muscles of the chest wall as it is elsewhere in the body.

The fascial planes also favour the spread of surgical emphysema, a condition usually due to air escaping from a perforation of the lung, the trachea or the œsophagus. The clinical features and X-ray appearances of air in the tissues are well known, and the condition itself is not dangerous although it may extend from the head to the legs and cause discomfort. It should be regarded as a pointer directing a search to its origin.

Bruising of the chest wall needs no special treatment, but a subfascial hæmatoma is more serious. It should be evacuated early and the bleeding points secured, because, if treated conservatively, the hæmorrhage is apt to continue and the loss of blood, by spread in the fascial planes, becomes serious.

The usual source of bleeding is the intercostal vessels. These are so intimately connected with the ribs for the greater part of their course that, in practice, they are seldom damaged unless a fracture has occurred. But, between the bodies of the vertebræ and the angles of the ribs, the intercostal bundles are separated from the bones, and a penetrating wound in this region may cause bleeding without a fracture.

The blood may escape to the surface if a superficial wound is present, but if not the pleura may be damaged and a hæmothorax will develop. It is occasionally necessary to do a thoracotomy in cases of the second type in order to find and control the bleeding points.

External hæmorrhage is obvious and invites early treatment, but bleeding into the pleural cavity is concealed and difficult to assess. In addition to the clinical and X-ray evidence, some idea as to the rate of bleeding can be had by taking the intrapleural pressures on several occasions. A hæmothorax due to a torn intercostal vessel is liable to be progressive, and differs in this respect from one due to hæmorrhage from the smaller pulmonary vessels. The latter is generally controlled eventually by local atelectasis of the wounded lung and the low pressure in the pulmonary circulation.

In the presence of an open wound of the chest wall some measure of emergency control can be achieved by introducing a pouch of material into the wound and packing it with gauze so that it spreads out upon the deep surface of the rib like a mushroom which can be pulled against the bleeding point.

In every case an early operation is necessary and the bleeding vessels must be secured when the wound has been excised. If the fracture of the rib is not comminuted, sutures can be passed round it to include the vessels and tied on either side of the bleeding point. When the rib has been shattered the loose fragments should be carefully removed and a small piece of normal rib taken out subperiosteally on either side of the fracture to expose both ends of the vessels.

Important hæmorrhage from the internal mammary bundle is not common because wounds which involve these structures are also likely to injure the heart or the large vessels. When it does occur the blood may escape to the surface, pass into the pleura or the pericardium, or form a hæmatoma in the mediastinum. Operation is needed for all these conditions.

Fractures.—With fractures the mechanical stability of the thoracic cage is often so impaired that a special element of risk arises on this account.

The bones form a series of hoops the strongest parts of which are the sternum and the vertebral column. For this reason crush injuries are more likely to break the ribs than the other bones, irrespective of where the force is applied.

In children the chest wall is so flexible that it may transmit crushing forces to the internal organs without breaking the bones and without much sign of superficial trauma; but in adults this is not so likely to happen except in the lower part of the chest where the diaphragm may be torn or the liver ruptured.

Simple fractures of the ribs are common and two different types may be observed; these are called "direct" and "burst" fractures.

When a force is applied to a rib the bone may break and the fragments be driven inwards at the point of impact, and if several adjacent ribs are involved in this way a

" stove-in " chest occurs ; on the other hand, the force may be transmitted round the rib to its weakest part at which it will burst outwards.

Burst fractures are most common in the upper part of the chest ; they occur near the angles of the ribs because the leverage is greatest here, and they may be overlooked if the X-ray pictures are not carefully examined. They are seldom comminuted, but are clinically important because they cause pain and sometimes a hæmothorax.

There are two serious conditions which may accompany and complicate fractures of the ribs. The first is traumatic asphyxia which is relatively common in these days when casualties may lie buried under debris for so long, and the second is acute dilatation of the stomach. The special danger of the latter is that, if coughing is painful or ineffective, the vomit may be partly inhaled.

In the case of simple fractures the surgeon is not concerned with the questions of reduction or union ; their importance lies rather in the fact that the movements of breathing may be limited by pain or rendered ineffective by an unstable chest wall.

To control the pain of fractures in the lower chest the skin should be shaved and strapping applied horizontally from points beyond the mid-line in front and behind. The object of this treatment is to prevent movement and, consequently, a wide area should be covered and the adhesive put on from below upwards with the chest in full expiration.

The other indication for immobilizing a part of the chest is less well known ; it is " paradoxical movement ", a condition which occurs when a series of adjacent ribs have been fractured, or removed surgically, so that the chest wall is unsupported. In such cases the affected part does not move with the rest but is sucked in during inspiration and blown out during expiration, and this causes dyspnœa and cyanosis because the cardio-vascular system and the mechanics of respiration are disturbed. Treatment aims at padding and strapping the unstable part so that it no longer moves. A serious case I have seen was a seaman who was blown from the bridge of his ship by the explosion of a mine, and sustained fractures of all ribs from the second to the tenth on the left side ; this man was admitted with advanced shock, dyspnœa and cyanosis, the skin of his chest wall was bruised but intact, and " paradoxical movement " was very marked. He was given a transfusion, oxygen to breath, and the left chest was immobilized ; his general condition improved immediately and he made a good recovery.

In war surgery compound fractures of the ribs are usually due to penetrating foreign bodies. Their treatment is often neglected partly because more serious injuries are present as well, but also because the surgeon is frightened of creating or enlarging an open wound of the pleura. This fear is misplaced and there are good reasons why " surgical revision " is a matter of importance. The intercostal vessels are probably bleeding and fragments of the rib may have been driven into the lung where they act as sequestra and cause pulmonary suppuration if they are not removed. In the case of bullet wounds the outlook is always more serious if a rib has been hit than if the missile has passed neatly through an intercostal space, because the bullet is deviated from its true flight and increases its destructive power by acquiring a rotation round its short axis.

The gravity of thoracic wounds which involve the vertebral column depends upon whether the spinal cord has been injured. If the cord is divided the prognosis is bad and in my experience little can be done to save these patients. The same is true of compound fractures of the sternum, a condition which is rare, for the patient does not often survive to reach a surgeon. Simple fractures of the sternum are more favourable ; they cause local pain, ecchymosis and sometimes a palpable deformity. If the fracture is transverse the lower fragment may be displaced and ride up in front of the upper, and treatment consists in strapping the part and keeping the patient in hyperextension, provided the associated pulmonary injuries do not make this impossible.

Open wounds of the pleura.—The second group of wounds, which are serious on account of their liability to disturb the cardio-respiratory systems, is that called " sucking wounds ". These are so grave that they colour the whole picture of traumatic thoracic surgery, and it is generally true that the life of the patient hangs upon their accurate treatment.

The diagnosis is seldom in doubt except in those cases where the missile has travelled some distance in the subcutaneous tissues before entering the chest, or when the wound is at the back and a hæmothorax is present. In the latter case, when the patient is lying on his back, the pool of blood in the pleural cavity blocks the hole and little air gets into

the chest until the patient is disturbed or placed on the operating table. For this reason the patients are relatively better than those with open wounds in the front of the pleura unless, and until, they are disturbed.

All surgeons are agreed that sucking wounds should be closed because the condition of the patient is at once alleviated by any treatment which prevents air being sucked in and out. The reason for the improvement which occurs is not clear at first sight, since it is known that under certain conditions an open pneumothorax is not dangerous in man. A wide thoracotomy can, for instance, be performed in some patients under local or spinal anæsthesia, and some men who were evacuated from Dunkirk without treatment were alive five or six days later in spite of an open wound of the pleura. The explanation of these apparent anomalies lies in the fact that in man, during *quiet* respiration, an open pneumothorax does not embarrass the circulation or the respiration beyond the points of their reserve. If the burden of shock, painful respiration, hæmorrhage, bronchial obstruction (by blood or secretions), or sepsis is added to an open pneumothorax the load is too great and the result is immediately serious.

The best way to close an open pneumothorax in an emergency is to cover the wound with a pad, and it is convenient to carry a standard dressing for this purpose ; it consists of a piece of mackintosh tissue to one side of which several layers of vaseline gauze have been sewn. This dressing should be strapped over the wound.

If the patient is seen soon after injury and resuscitation has been successful the pad should be taken off, the wound carefully and thoroughly excised, and then closed by suture of muscle and perhaps skin. In every case an intercostal catheter should be inserted because whenever the pleura has been opened by trauma it is liable to infection and also because a transient blood-stained effusion is common. Closed drainage with a water seal should be maintained for about forty-eight hours. It has been established that an intercostal tube can be kept in the pleural cavity for forty-eight hours without causing infection provided the drainage apparatus is sterile. At the end of this time a little fluid from the tube should be aspirated with a needle and syringe and examined microscopically, and if no organisms are detected the tube should be taken out of the pleura, and the hole closed with a stitch. If organisms are present drainage must be continued. This procedure enables the original wound to heal even though an empyema may be forming.

As a general rule the pleural cavity should not be drained through a sucking wound. The objects of treatment are to achieve healing of the wound and airtight drainage of the chest. If the pleura is drained through a sucking wound both things are prejudiced.

If the wound is large and cannot be closed by muscle or skin after excision it must be covered and rendered airtight with a large pad of vaseline gauze, and the pleural cavity drained as before. The prognosis is, of course, influenced by the size of the defect in the chest wall but patients with large wounds sometimes get well, particularly if the lung has not been damaged and can be sewn to the surface at the margins of the gap. In such cases plastic operations on the chest wall will be necessary later on.

When infection is already established or probable an open wound of the pleura must still be " closed " but the meaning of the word is now particular. *The wound must be left surgically open, so that pus and exudates can escape, but closed with an airtight dressing.* The common mistake is that the surgeon, influenced by his knowledge that an open pneumothorax is dangerous, sews the muscles or the skin over the hole. This practice is doubly dangerous because it engenders sepsis in the chest wall as well as in the pleura. Intercostal drainage is, of course, essential. When the patient has overcome the superficial infection the sucking wound should be treated by secondary suture, an operation which can be undertaken in the presence of a properly drained empyema.

There is one further and important point concerning the management of sucking wounds. As a rule suture can include both muscles and skin after *efficient* and *early* excision. But this does not apply to patients who have to be evacuated soon after operation, with the possibility of a journey of several days without careful supervision. For these it is wise to sew the muscles over the defect but *not the skin*, and to cover the wound with a pad and strapping. Delayed primary suture can then be done at the base hospital.

Mr. J. E. H. Roberts said that a considerable number of cases of blast had now been studied. Some of these cases did not develop serious symptoms for forty-eight hours.

The blast was in many cases a progressive lesion ; capillary bleeding into the lung went on for several days. Professor Hadfield had made post-mortem examinations in thirty-eight cases of blast, in some of which death had taken place immediately, while in others there had been survival for several days. It was quite clear that the length of time after the blast injury before death occurred had a direct relation to the amount of hæmorrhage in the lung. Some of the cases seen at the hospital showed minute punctiform hæmorrhages in the skin of the abdomen and chest. If such a condition, which was not very easily seen, was observed it might be assumed that the patient was suffering from blast until the contrary was proved. Some of the cases had severe abdominal symptoms with little to draw attention to the chest, gross rigidity and tenderness of the abdominal wall, with no shifting dullness in the flank or absence of liver dullness. He had knowledge of two of these cases in which a laparotomy was performed without any lesion being found, and it was possible, although there was as yet no proof of it, that these symptoms were due to the hæmorrhages into the muscles of the abdominal wall similar to those into the intercostal muscles. Less severe degrees of abdominal rigidity were common. Some of the post-mortem examinations had shown the intercostal muscles to be infiltrated with blood. One patient, who subsequently died, was so excessively tender all over his chest wall that it was impossible to examine him thoroughly because of the intense pain caused by movement. The post-mortem examination showed the same condition of hæmorrhage between the ribs. Blast, therefore, should always be borne in mind in dealing with any batch of bomb-wounded people. No operation should be performed under a general anæsthetic until it was shown whether the blast of the lung was progressive. Blast had been overlooked in many cases because its presence was not suspected. The addition of a general anæsthetic to the already existing lesion was not conducive to the recovery of the patient.

In the most severe type of case, cyanosis, dyspnœa and tachycardia, with moist sounds all over both lungs, were present. With the less severe, apart from tachycardia, the lesion might easily be missed, and yet severe symptoms might supervene after forty-eight hours. An X-ray examination of the lung was the best possible means of diagnosis, as even in the very early cases diffuse mottling or mottling combined with larger areas of opacity were seen.

A second condition which must be taken into account was carbon monoxide poisoning ; four of the post-mortems done by Professor Hadfield showed this condition. The carbon monoxide was derived in some cases from broken gas mains, in others from an explosion gas acting in a confined space. Again in this condition no general anæsthetic should be given, but oxygen combined with 5% carbon dioxide should be administered forthwith.

Dr. M. D. Nosworthy : On the subject of anæsthesia for war casualties with chest injuries, since time is short, I will only touch on three important points.

First, I have seen no ill-effects arise from the use of pentothal sodium—in spite of its sulphur content—in patients who are " blue " from the previous administration of one of the sulphonamide group of drugs. Of course, in view of its marked respiratory depressant action, its use may be contra-indicated on other grounds and in no instance have I injected more than ½ grm.

Secondly, the presence of copious tracheobronchial secretion has seldom been a prominent feature in our series of cases and in the great majority of patients I have just used a pharyngeal airway. When secretion is present, however, an endotracheal anæsthetic with provision for adequate suction is essential. I have in these cases had no difficulty in passing a large oral Magill cuff-tube by direct laryngoscopy, and the statement in a recent article on this subject that tracheotomy must be performed, if " blind nasal intubation " fails, is, in my opinion, very wrong and sufficient condemnation in itself of the anæsthetic technique there put forward.

Aspiration of the tracheobronchial tree may be a life-saving procedure in any patient who is incapable of coughing his pulmonary secretions effectively—for instance, as a result of multiple rib fractures. A tablet of decicain may be given to such a patient to suck, and then his nose and throat sprayed with 20% cocaine. Blind nasal intubation may then often be effected without disturbing the conscious patient propped up in bed, and the secretions aspirated by passing a suction catheter down through the lumen of this endotracheal tube. If this treatment has not been too long delayed, improvement in the

patient's breathing, pulse, and colour is dramatic. Aspiration is repeated as often as necessary until coughing again becomes effective.

Finally, during operation one has often to compete with a chest widely opened in a patient who usually has a freely mobile mediastinum. Oxygen want of some degree is commonly present before operation and the development of "paradoxical respiration" when the chest is opened may well have fatal consequences as a result of ever-increasing anoxia and carbon dioxide accumulation.

In practically all these war cases, therefore, I have used "controlled respiration" during anæsthesia, using the carbon dioxide absorption technique, for this is the only method I know which permits normal respiratory physiology to take place while the chest wall is wide open. In controlled respiration the anæsthetist, having abolished the active respiratory efforts of the patient, carries out an efficient respiratory exchange by squeezing the breathing bag rhythmically by hand. This method completely prevents paradoxical respiration, mediastinal flap, and all disturbance from sucking wounds. Both pleural cavities can be opened simultaneously without harm. The patient's existing vital capacity is used to the full. In view of the adequate oxygenation and efficient removal of carbon dioxide, even very ill patients stand up to prolonged operations so well that one has come to expect them to be no worse, and commonly better, at the conclusion of the operation. The surgeon's work inside the chest can be made less difficult, and at the end it is almost always possible, if one so desires, to leave the lung on the affected side fully expanded. Since controlled respiration is so beneficial in this type of work and is used but little in this country I will try to explain briefly how it is done.

Respiration[1] depends essentially upon two variable factors: (1) The respiratory threshold or the sensitivity of the respiratory centre, and (2) the stimulus activating the respiratory centre—and for the purposes of this explanation we need only consider carbon dioxide as the respiratory stimulus. Normal breathing takes place when the CO_2 and the sensitivity of the respiratory centre are both normal, or so long as they bear a normal relation to one another, as still occurs when the stimulus and the threshold are both raised or lowered a similar amount.

Active respiration can be abolished by (1) decreasing the CO_2 and so lowering the stimulus, (2) using respiratory depressant drugs and so raising the threshold, or (3) a combination of both (1) and (2) to a lesser degree.

Dr. Crafoord of Stockholm uses the last method by giving large doses of morphine and codeine in order to raise the threshold, and then by means of the spiro-pulsator hyperventilating the patient and so lowering the stimulus. I think that such hyperventilation is inadvisable in these war cases, for the lung tissue is often contused, and hæmorrhage and further damage might result from this treatment. I concentrate, therefore, in the main, on raising the threshold by the use of respiratory depressant drugs.

All these patients have received a hypodermic injection of morphine (or omnopon) and scopolamine with or without an intravenous injection of pentothal sodium before the inhalation anæsthetic is started. To practically all I have administered cyclopropane which, besides being a potent respiratory depressant, is non-toxic, of short action, and permits the use of a high concentration of oxygen in the anæsthetic mixture.

Unless contra-indicated, I employ some re-breathing for a minute or two during induction, and the rise in CO_2 stimulus from this maintains respiration in spite of the coincident rise in the threshold from the depressant action of the cyclopropane. When the breathing is shallow I augment it by manual bag-pressure during the inspiratory phase. At the end of this interval I insert a canister containing soda-lime, which absorbs CO_2, between the mask and the breathing bag. The CO_2 promptly falls and if the divergence between the stimulus and the threshold is sufficient, active breathing ceases. Before the carbon dioxide has had time to bank up sufficiently to reactivate the respiratory centre, I squeeze the breathing bag and produce an artificial inspiration. During the passive expiration which naturally follows the accumulating CO_2 is again removed by the soda-lime.

[1] Nosworthy, M. D., "Some points about respiration", *St. Thomas's Hospital Reports*, 1939, **4**, 164.

This intermittent bag-squeezing is continued rhythmically about 20 times per minute, although on occasion it may be interrupted for a minute or so and the lungs left completely at rest if the surgeon is doing a difficult suture deep in the chest. If the pulmonary inflation is carried out gently, the lung on the normal side can be fully expanded whereas the lung compressed by a hæmothorax remains collapsed, yet this can in almost every case be re-expanded easily—when required towards the close of the operation—by *slightly* more forcible bag pressure. If great pressure would be required to re-expand the lung it may be better to leave it collapsed rather than to risk damaging it. The presence of atelectasis may be the deciding factor which prevents re-expansion of a collapsed lung.

In order to restore normal breathing and to allow the patient to wake up I bring the respiratory threshold and the stimulus back to their normal relationship. I usually accomplish this by switching to nitrous oxide anæsthesia in the later stages, and this practice also enables me to forecast whether the patient is likely to require post-operative oxygen therapy or not.

Controlled respiration can be used with any anæsthetic agent, and although it presents no real difficulties once the principle has been grasped, the technique should, in my opinion, be mastered during simple operations on fit subjects.

Mr. O. S. Tubbs said that he felt Mr. Price Thomas had been very optimistic in recommending that primary operations should be done within six hours of the infliction of the wound. Undoubtedly this was the ideal to aim at, but he knew of one Chest Centre where no case had been received within this period and yet many successful primary operations had been performed. Reference to this time interval raised the very important question as to whether the transport of patients with chest wounds by ambulance was dangerous. In the speaker's experience this danger had been grossly exaggerated ; patients travelled very well in a good ambulance *provided* shock had been overcome first.

Mr. Price Thomas had been asked if he had any criteria by which he determined the advisability of thoracotomy in cases of penetrating wounds with retention of the foreign body in the lung. All were agreed that large missiles caused much pulmonary laceration and often carried fragments of clothing and rib into the lung and that these cases required thoracotomy. On the other hand minute fragments often penetrated an intercostal space, produced little tissue damage and very rarely introduced infection ; obviously these cases did not require operation. But the decision whether to operate on those patients with wounds falling between these two groups was often most difficult.

In most people's experience crush injuries were forming an increasing proportion of chest wounds. Some of these had been very severe, with gross displacement of the fractured rib fragments which lacerated the lung and caused a hæmothorax. These injuries when not compound had been treated simply by strapping with apparently satisfactory results. The speaker asked Mr. Price Thomas if he advocated surgical revision of such injuries.

Mr. Price Thomas (in reply) : Mr. Tubbs raised the question as to whether six hours is not too short a time limit. Undoubtedly many cases will be operated on beyond this set limit, in fact, many cases have been done at a later time in our own unit. Despite this I feel that this is the ideal limit of time, as the best results are achieved by operations done within this limit, and operations done at a later period demand a great sense of judgment and experience, experience which is easily available should the occasion arise.

The question of the size of the foreign body to be removed is difficult to answer. I conclude it will vary with the individual surgeon. I would not suggest for a moment that minute foreign bodies should be submitted to operation, but sizable ones in the presence of a hæmothorax should, I maintain, always be removed by operation. Some of these foreign bodies may be and do become encapsuled, but a percentage, which at present we have no means of determining, are the direct cause of the early and late morbidity.

The stove-in chest in which the skin is intact, even with a hæmothorax, should not be operated on, but as both Mr. Barrett and Mr. Tubbs state, they should be strapped and the hæmothorax treated conservatively as has been described.

Pre-operative radiography is very valuable and can be done in every case with little or no disturbance. The draw sheet in the bed makes an ideal agent for lifting the patient; four people, one at each corner to keep the sheet taut, can lift very heavy patients without discomfort.

My attention has been called to an apparent discrepancy between my statement and Mr. Barrett's as to the sewing up of wounds in the chest wall, but it is only apparent. My remarks refer only to those patients treated during the first six hours, and an efficient surgical revision of the wound down to the pleura is postulated. The wounds I advocate sewing up are those which lie at the site of the projected thoracotomy, when the wound itself is used for this purpose, and it falls into the group of open sucking wounds where the chest must be closed to counteract the hæmothorax. I agree entirely with Mr. Barrett that wounds of the chest wall which do not constitute sucking wounds should not be sewn up, and even in the group above sutures should be well spaced and not tied tightly.

Section of Pathology

President—G. W. GOODHART, M.D.

[*October* 15, 1940]

DISCUSSION ON INFECTION OF WOUNDS

Professor A. A. Miles: The evidence I have to offer on the subject of wound infection, though not yet complete, is nevertheless suggestive enough to warrant certain conclusions. It consists of observations that have come our way during an attempt firstly to follow the course of chemotherapy of wounds by bacteriological methods, and secondly, to measure the importance of wound infection contracted in hospital. So far we have obtained little information on chemotherapy; the material admitted to hospital is too heterogeneous and the patients are subjected to too wide a variety of treatments before admission. The evidence for hospital infection, and for cross-infection of wounds, is better, and I should like to discuss it to-day.

Our first attempts on this problem were directed to measuring the amount of air-borne cross-infection, but the many channels of contact infection we discovered in the wards made the measurement of air-borne infection impossible until all the other channels were stopped, and our attention was directed to hospital infection of all kinds. Now both the fact of hospital infection of wounds—and the word "hospital" here embraces all the environment of a wound from the time it comes under treatment, including even first aid—and the channels of such infection have been recorded many times in the past; but in this war we have the advantage of a detailed serological division of one of the most important species pathogenic in wounds, namely, the hæmolytic streptococci, which enables us to trace the spread of streptococcal infection with some precision. By assigning each streptococcus isolated to its particular Griffith's type (Griffith, 1935), we can sometimes trace the origin and spread, not only of manifest, but also of latent infection.

Evidence of hospital infection.—Hospital infection may be inferred on two grounds, clinical and bacteriological; clinically, by the sudden addition of a new symptom complex referable to infection, with or without the demonstration of newly appearing bacteria in the wound; and bacteriologically by the demonstration of newly appearing bacteria, in the absence of any gross change in the patient's condition.

Both changes are open to another interpretation, namely, that the bacteria responsible for the added signs, or the bacteria newly discovered in a relatively old wound, have merely

grown out from microbes introduced at the time of wounding. There is no direct proof or disproof of this notion, because there is no infallible culture medium which can be guaranteed to bring out these hypothetically minute inocula of bacteria when the wound is first swabbed. The indirect evidence for hospital infection, as against a late manifestation of latent, initial infections, is as follows :—

(1) The hypothetical initial infection would have to remain latent for as long as three to four weeks, and the bacteria that, in fact, appear late (staphylococci and streptococci) are not those given to lying latent in freshly infected tissues.

(2) It is sometimes possible to demonstrate the apparent spread through a ward of an infection by a relatively rare type of organism.

(3) The bacteria commonly appearing late are those commonly carried by hospital personnel in nose, throat, and on the skin, and failures of prophylactic technique occur even in the best run surgical wards and theatres. This combination of circumstances offers ample opportunities for infection.

The hypothesis of hospital infection, in fact, puts less strain on the imagination.

My evidence was obtained mainly in a study of a large ward of an E.M.S. hospital. For a great deal of the data I have to thank my colleagues, Dr. Joyce Wright, Dr. Herta Schwabacher and Dr. A. C. Cunliffe. Dr. F. Griffith has kindly typed all the hæmolytic streptococci isolated.

The bacteriological state of the wounds to which bacteria are added in hospital is shown in Table I, which lists the percentage of frequency of various bacterial species in

TABLE I.—FREQUENCY OF BACTERIAL SPECIES IN SWABS OF WOUNDS TAKEN ON ADMISSION TO ADVANCED BASE HOSPITALS IN ENGLAND.

Type of bacterium	Percentage times found in 105 Military wounds	+	49 A. R. wounds	=	154 wounds (total)
Strep. hæmolyticus	31·4	..	14·3	..	25·3
Viridans and non-hæm. strep.	18·1	..	6·1	..	13·9
Staph. aureus	54·3	..	55·1	..	53·3
Staph. albus, &c.	19·0	..	40·8	..	25·4
Gram-negative cocci	1·0	..	2·0	..	1·3
Diphtheroids	7·6	..	18·4	..	10·8
Coliforms	24·7	..	14·3	..	20·8
Proteus vulgaris	6·7	..	6·1	..	6·3
Ps. pyocyanea	7·6	..	6·1	..	7·0
Hæmophilus	1·0	..	0·0	..	0·6
Aerobic spore-bearers	14·3	..	16·3	..	14·5
Cl. welchii	22·8	..	4·1	..	16·4
Cl. sporogenes	10·5	..	4·1	..	8·2
Cl. septique	3·8	..	0·0	..	2·5
Other Clostridia	4·7	..	8·2	..	5·2
STERILE	11·4	..	4·1	..	8·8

admission swabs of military and air-raid casualties. The table does not record the relative predominance of the various species : in general, the commonest colonies on plates made directly from swabs were *Staph. aureus*, *Strep. pyogenes*, Clostridia (mainly *Cl. welchii*) and coliforms. There is a curious difference between the air-raid and Dunkirk wounds. *Strep. pyogenes*, coliforms and anaerobes occur with a much lower frequency in the former. How much of that is due to added infection in the Dunkirk wounds, which were swabbed rather later in their history, it is impossible to say without further analysis.

In these wounds, infected in a variety of ways, we had to look for added infections.

Examples of hospital infection.—Twenty representative wounds of troops, mainly gunshot and shrapnel, inflicted in Belgium and France, were followed bacteriologically by means of weekly swabs from the time of operation to the time of healing. One wound was initially sterile, the rest infected at the time of admission. Seventeen of the twenty became infected with additional bacteria. The frequency with which the additional organisms appeared in the seventeen cases was as follows: *Staph. aureus* 9, *Strep. pyogenes* 8, aerobic spore-bearers 3, *Ps. pyocyanea*, non-hæmolytic streptococci, micrococci and diphtheroids 2 each, and anaerobic spore-bearers and coliforms once each. The two most frequent of these secondary invaders, the streptococci and staphylococci, are organisms commonly carried in the human upper respiratory tract. The additional bacteria appeared between three and twenty-seven days after the initial swabbing, and in 7 cases the appearance was accompanied by local and constitutional signs of infection. In these seven cases the additional organism was *Strep. pyogenes* 3, *Staph. aureus* 3 and *Ps. pyocyanea* 1.

TABLE II.—CHANGES OF FLORA IN A PLASTER CASE. WOUNDS OF LEG AND THIGH.

Date		Flora
25.5.40	Plaster	
30.5.40	Replaster	*Staph. aureus*, Strep. 27.
15.6.40	Replaster	
1.7.40	V. ill	*Staph. aureus*, Strep. 1, *Proteus vulgaris*
5.7.40	Plaster off Amputation; replaster	*Proteus vulgaris, Bact. coli, Cl. welchii*, diphtheroid
16.7.40	Stump	Strep. 27, *Proteus vulgaris*
22.7.40	Stump	Strep. 27, *Proteus vulgaris*
29.7.40	Replaster	Strep. 27, *Proteus vulgaris*, diphtheroid, *Staph. albus.*

Similar changes took place in plaster-treated wounds. Table II shows the bacteriological history of one plaster case, which is quite characteristic. Another, originally infected with *Staph. aureus*, yielded *Ps. pyocyanea* after thirteen days, and *Proteus vulgaris* and a Group C hæmolytic streptococcus after twenty-six days.

Examples of traced streptococcal infection.—In a large double ward, eleven of 55 patients had a streptococcal wound infection. In 8 of these the infection was apparently acquired in hospital. One group of 5 were infected with a Strep. 27 (i.e. hæmolytic *Strep. pyogenes*, Griffith's Type 27). The weekly swabbing results in this group were as follows: —

JA. Bed 29. *Wound Swabs*

2.6.40	*Strep. fæcalis, Staph. aureus*
10.6.40	*Staph. aureus*, Strep. 27, aerobic spore-bearer
24.6.40	*Staph. aureus*, Strep. 27
1.7.40	*Staph. aureus*, Strep. 27
8.7.40	*Staph. aureus*

JS. Bed 32. *Wound Swabs*

2.6.40	*Cl. sporogenes*, micrococci, Strep. Group C, *Ps. pyocyanea, Staph. aureus, Bact. coli.*
10.6.40	*Ps. pyocyanea, Staph. aureus*, Strep. 27
24.6.40	*Ps. pyocyanea, Staph. aureus*, Strep. 27
1.7.40	*Ps. pyocyanea, Staph. aureus*, Strep. 27
8.7.40	*Ps. pyocyanea, Staph. aureus*, Strep. 27
15.7.40	*Ps. pyocyanea, Staph. aureus*, Strep. 27
25.7.40	*Ps. pyocyanea, Staph. aureus*, Strep. 27

DI. Bed 34. *Wound Swabs*

2.6.40	*Bact. coli, Ps. pyocyanea*
5.6.40	*Bact. alkaligenes, Bact. aerogenes*
12.6.40	*Bact. aerogenes, Ps. pyocyanea,* Strep. 27
25.6.40	Strep. 27
1.7.40	Strep. 27
8.7.40	Strep. 27
15.7.40	Strep. 27
22.7.40	Strep. 27

BB. Bed 11. *Wound Swabs*

26.6.40	Strep. 27
1.7.40	Strep. 27
8.7.40	Strep. 27
15.7.40	Strep. 27

The first swab was taken three weeks after admission. No direct evidence of a hospital infection.

JM. Bed 66. *Wound Swabs*

10.6.40	Non-hæmolytic strep. *Staph. aureus*
24.6.40	Strep. 27
1.7.40	Strep. 27, *Ps. pyocyanea*
4.7.40	Strep. 27, *Ps. pyocyanea*
7.7.40	Strep. 27, *Ps. pyocyanea*
15.7.40	Strep. 27, *Ps. pyocyanea*
22.7.40	Strep. 27, *Ps. pyocyanea*

The beds of the first three patients were close together, and the fourth only 24 feet from Bed 29, diagonally across the ward. The bed-proximity associated with an outbreak of *Strep. pyogenes* infection is reminiscent of outbreaks of streptococcal infections investigated, e.g. in otolaryngeal wards by Okell and Elliott (1936), in scarlet fever wards by Allison and Brown (1937), and in children's wards by Wright (1940). At the time of the outbreak no other type 27 streptococcus was isolated from the wounds in the two wards. Nor, with two exceptions, was it found in the throats of the nurses or men, from 18.6.40 to 6.8.40. The two exceptions were the patient BB himself, whose throat harboured Type 27 on 2.7.40, and the patient OJ.

OJ. Bed 51. *Throat Swabs*

18.6.40	No hæmolytic streptococci
25.6.40	One colony Strep. 27
2.7.40	No hæmolytic streptococci
9.7.40	A few colonies Strep. 27

OJ appears to have been a carrier of small amounts of Type 27, and may have been the source of all five Type 27 wound infections, including the case in Bed 66. It is noteworthy that in three instances, Strep. 27 was accompanied by *Ps. pyocyanea*; the two may have been transmitted together.

This evidence is more impressive in the light of a survey of the whole ward, patients and personnel, for Strep. 27. This general survey was started on 18.6.40, when throat swabs were taken from all inhabitants of the ward, and repeated at about weekly intervals. Table III summarizes the throat history of the ward from that date. There was no

TABLE III.—PATIENTS, NURSES AND SURGICAL STAFF CARRYING HÆMOLYTIC STREPTOCOCCI IN THE THROAT.

Each double initial represents one person carrying the streptococcus indicated at the head of the column.

	Griffith's types								Lancefield's groups			
Date	1	2	4	9	11	14	22	27	C	G	H	Unclassified
18.6.40		FD		RQ	AZ	MB						
25.6.40	HM	FD	FM	RQ	AZ	MB		OJ				
2.7.40				RQ	AZ	MB		BB	FD	NG		
9.7.40				RQ		KR		OJ	FD			NG, NR
16.7.40						MJ					ML	
23.7.40							HS					
30.7.40									CL			

prevalence of any one kind of streptococcus, and in view of the same weather conditions, the same population and density of population in the ward, we can safely assume that no such prevalence existed in the fortnight prior to 18.6.40.

In the light of Table III, other typed streptococci found in the wounds have a certain value as indicative of cross-infection. For example, on 5.6.40 the patient in Bed 9 had a Strep. 4 and *Staph. aureus* infection of his wound. On 12.6.40, the patient in Bed 8 acquired a Strep. 4, in a wound originally infected with *Cl. welchii* and *Cl. sporogenes*: and Strep. 4 was found nowhere in the ward except in the throat of the patient in Bed 4, twelve days later. Again, the patient AZ, the only throat carrier of Strep. 11 in the whole ward, carried it in his throat on 18.6.40. On 26.6.40 his amputation stump, originally infected with *Cl. welchii* and *Bact. coli*, suppurated, yielding Strep. 11. Both stump and throat were apparently clear by 8.7.40, but the patient opened a foot-blister with his penknife, and on 15.7.40 this suppurated, yielding Strep. 11. Here we have an apparent transfer from one site to another in the same patient.

Sometimes the acquisition of a streptococcus is unaccompanied by any disease. But in a small streptococcal spread in another ward, at present under investigation, a sudden retardation of healing in a healthy granulating wound, clinically observed in three patients, was later found to have started at the same time that an added streptococcus was cultivated from the wound.

Whether infection is spread by contact or is air-borne, it seems fairly certain that the air at any rate receives pathogenic bacteria when the dressings and blankets of infected patients are manipulated. In a few experiments made by Dr. Wright plates were exposed near beds during certain procedures. The general air of the ward yielded nothing more pathogenic than 12 colonies of *Staph. aureus* during exposures of over 150 plates made at all times of the day and night. In Table IV are summarized the results of 22 plate

TABLE IV.—AIR PLATES EXPOSED NEAR THE BED OF PATIENTS DURING CERTAIN PROCEDURES.

Procedure	Bacteria in wound	Pathogens on air plates
Wound Dressing —		
14 Tests :	(1) Strep. 27	Strep. 27 (3 colonies)
3 Positive	(2) Strep. 4 and *Staph. aureus*	Strep 4 (2 colonies)
	(3) *Staph. aureus*	*Staph. aureus*
Plaster changing—		
3 Tests :	(1) Strep. C., *Staph. aureus*, Proteus	Strep. C. (5 colonies)
3 Positive	(2) *Staph. aureus, Strep. pyogenes*, Proteus	Proteus
	(3) *Staph. aureus, Strep. pyogenes*, Proteus	Proteus
Bed-making—		
5 Tests :		
1 Positive :	(1) Strep. 9 (Patient not in bed at time)	Strep. 9 (3 colonies)

exposures, during wound dressing, plaster changing and bed-making. In each group of tests there are positive air-plate results indicating the dressing or blankets as a source of pathogenic air-borne bacteria.

Finally, I must apologize for the inconclusive nature of some of the evidence I have presented. We are getting better evidence, and my excuse for presenting the best so far obtained is the hope that others may be induced to add to it.

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Dr. E. T. C. Spooner: During the last week of May and the first fortnight of June a group of wounded soldiers from France arrived at the hospital. Shortly after admission many of the limb wounds were explored, foreign matter was removed, tracks and pockets were laid open, sterile vaselin gauze was applied and the limb was encased in plaster. The wounds were all four or five days old at the time of admission and most of them had not been given more than a first field dressing *en route*.

Unfortunately systematic bacteriological examination of these cases did not begin until early July, when most of them had been in plaster for a month. Even so one or two points of general interest have appeared to justify comment.

The work was undertaken for the War Wounds Committee of the Medical Research Council by Professor Paterson Ross and myself.

During July and August, thirty plaster cases were examined bacteriologically whenever their plasters were changed or removed. Samples were taken by swab or glass spoon and inoculated on to aerobic and anaerobic blood-agar plates and into Robertson's cooked meat medium.

The pus within a plaster is often copious. It may be fluid and yellow, or, later, an inspissated brown cheesy material composed almost entirely of bacterial bodies.

The smell is usually foul. The bacteria which contribute to it are Clostridia, especially *Cl. sporogenes*, coliform bacilli, staphylococci, diphtheroid bacilli, Proteus and *B. pyocyaneus*, all of which produce strong odours, and several of which are usually present in a plaster.

The commonest aerobic bacteria inside the plasters were staphylococci, most of them coagulase-positive, *Strep. hæmolyticus*, diphtheroids of various kinds, and coliform bacilli. These bacteria seemed to do the patients little active harm except when they were shut in abscesses or pockets. There is, however, a suggestion that those patients whose wounds were infected with hæmolytic streptococci were not so well as others. The other bacteria present were distributed without reference to severity of illness.

Anaerobic sporebearers have been obtained from the cooked meat cultures from most cases, but they are generally present in small numbers. *Cl. welchii* was, however, obtained from three, in two of them in numbers sufficient to appear on the primary anaerobic plate. There is no indication that the presence of Clostridia in these cases has proved harmful.

The change of flora at successive plaster changes is, at any rate after the first month of plaster treatment, small. Occasionally a new species has been obtained at a later change of plaster. Thus, three cases acquired a proteus, two a diphtheroid, one a *B. pyocyaneus*, and probably one a *Strep. hæmolyticus*.

B. pyocyaneus has been present in three other cases observed at more than one plaster change; it has not shown a tendency to increase at the expense of the other kinds of bacteria present.

All strains of *Strep. hæmolyticus* obtained have been sent to Dr. F. Griffith, for typing. A few strains from cases other than plasters—from open wounds, sore throats and apparently healthy throats of carriers—have been examined during the same period. A dozen types have been found to be present in the hospital; four have been fairly common, and their distribution among plaster cases suggests that "hospital infection" is occurring. It is impossible to say at what stage these plaster cases acquired their hæmolytic streptococci; but most of them had been treated by various means for four or

five days between the receipt of their wounds and the first application of plaster-of-Paris.

While this investigation was in process, a Type 11 streptococcus provided an example of "hospital infection". Two "clean" nerve surgery cases, operated on upon the same day and in the same theatre, showed signs of infection on the fourth and fifth days respectively after operation. A nurse in the operating theatre was found to be a throat carrier of this streptococcus.

It seems probable that enclosure in plaster fails to protect wounds much if at all against cross-infection in the ward. But even if they are protected against cross-infection, they may constitute a certain risk to other wounds in their neighbourhood, because the outside of a plaster is often quite thickly impregnated with streptococci of the same type as is present inside it.

This observation suggests that plasters should not be opened in wards or in theatres used for other cases. It also suggests that those who open plasters might, in self-defence, wear masks and take pains over the toilet of their hands and instruments.

Work on the bacteriology of plaster cases and of other wounds is still in progress at the hospital; but it is too early to speak of other aspects at this stage.

Dr. M. van den Ende: *The prevention of wound infection by reducing the number of air borne bacteria.*—The majority of wound infections depend upon entrance of bacteria at the time of wounding, or at a later stage from the hands of dressers, nurses and surgeons, or by direct contact with infected material. There can, nevertheless, be no doubt that air-borne bacteria are responsible for a large number of both primary and added or hospital infections of wounds.

It must be apparent that the first step in reducing air-borne infections is the elimination of those sources from which bacteria are disseminated into the air. These sources are multiple and include wound discharges, dressings, plasters, dust from floors, furniture and bedclothes, and in the case of organisms, such as staphylococci and streptococci, the upper respiratory tract of carriers.

Use of masks.—Pathogens from the respiratory tract are disseminated in droplets of varying sizes. The larger droplets settle out rapidly and have a limited range of infectivity of probably less than 15 ft. The projection of large droplets into open wounds can be prevented by the wearing of suitable masks by surgeons, theatre staffs, as well as those doing the ward dressings. Effective masks of cellophane and cellulose acetate mounted on light wire frames of spectacle type are easy to construct, and cause little or no discomfort to the wearer. The wearing of simple masks of this type is, however, not likely to prevent entirely the dissemination of fine droplets which, owing to their small size, evaporate rapidly leaving nuclei which remain in suspension for many hours (Wells). Gauze masks, provided they consist of four or more layers of gauze with a mesh of at least 48 to the inch, are also capable of preventing the dissemination of droplets from the respiratory tract, but are less comfortable than the spectacle type when they have to be worn for long periods.

Control of dust.—Dust has been known as a source of air-borne pathogens such as *M. tuberculosis, Staph. aureus* and streptococci, since the end of the nineteenth century. More recently the importance of dust in the spread of streptococcal infections has been shown by White (1936) and Cruickshank (1938). Blankets, as a source of dust-borne bacteria, are of special importance because of their intimate contact with the source of infection, and because the dust consists largely of minute fragments of wool fibres which may remain in suspension for a long time. Cruickshank has already stressed the importance of rounded corners, damp dusting and sweeping, and vacuum cleaning as well as the avoidance of uncovered woollen blankets in the reduction of air-borne infection.

An efficient, simple and inexpensive method of laying floor dust is the application of oil such as crude liquid paraffin to wood or linoleum floors. One quart of spindle oil is sufficient for the treatment of approximately 400 sq. ft. of wooden floor. The dust-laying properties after a single application remain maximal for at least three weeks and the duration of maximal effectiveness after subsequent applications is probably about a month or more (van den Ende, Lush and Edward, 1940).

Experiments recently performed with oil-impregnated blankets suggest that in this

connexion also the oil may have considerable dust-laying properties. Blankets "dry-cleaned" in a 30% solution of medicinal paraffin will retain approximately 3% by weight of the oil. Such blankets are not appreciably oily to the touch. They will, after artificial impregnation with bacteria or after several weeks' use in a dusty room, liberate, when shaken or beaten, one-tenth or less of the number of organisms liberated by control blankets similarly infected. The dust-reducing properties can be demonstrated also on other textiles such as cotton sheeting, but as the amount of dust obtained from sheets is usually less than from blankets the difference between test and control is less striking.

The use of dust-laying oils on hospital floors is suggested as a method which will significantly assist in reducing the number of air-borne bacteria. After suitable "field" trials of oil-impregnated blankets it is evident that these too may be of use in the reduction of cross-infections in hospitals. As dust interferes with the efficacy of physical and chemical methods of air sterilization the dust-laying oils can probably be used with advantage in conjunction with these methods.

Ventilation is the most effective method of reducing the number of bacteria already in suspension in the air as fine droplets, droplet nuclei, or on dust particles. Other methods can only be regarded as substitutes under conditions where sufficient ventilation is impossible, such as in operating theatres, and perhaps in wards during the winter months when windows and doors will remain sealed against cold, and during long black-out periods.

Use of ultra-violet light.—Of the physical methods of air purification, ultra-violet light, so strongly recommended by Wells, is highly effective against bacteria atomized from water or broth suspensions. In laboratory tests, using *Strep. salivarius* sprayed into a room of 800 cu. ft. capacity, for instance, a single ultra-violet lamp has been found to give a percentage kill in 20 minutes equivalent to a ventilation rate of 30 turnovers per hour. Ultra-violet light is, however, apparently much less effective against dry dust-borne bacteria. For this reason trials under working conditions, where the number of bacteria in the air of rooms depends on the state of activity of the occupants, have frequently been disappointing. The experiments which under similar circumstances have resulted in measurable reduction in the number of air-borne bacteria, are probably to be explained by the sterilizing effect of ultra-violet light on small dust-free particles and fine droplets from the respiratory tract. Ultra-violet light may, in this way, assist in the reduction of cross-infection, especially if used in conjunction with methods designed to eliminate the dust present.

Laboratory tests performed with ducts which include cloth filters for the removal of large dust particles and ultra-violet lamps within the duct have given reason to suspect that the method of combined filtration and ultra-violet light is highly effective. It has the additional advantage that the lamps are enclosed within the ducts. Ducts of this type have been installed over operating tables in such a way that a constant, though almost imperceptible current of sterile air is directed on to the table.

Use of antiseptic mists.—Antiseptics for killing bacteria in air are best used in the form of fine sprays. The germicide in a suitable solvent is atomized from machines designed to create a mist of fine particles. The bactericidal properties depend on collision between bacteria and antiseptic droplets—so that the larger the number of antiseptic particles, the more effective it is. Twort and his co-workers (1940) have found particles of 1 μ or less more effective than larger ones.

All commercially available machines are not capable of atomizing some of the organic solvents used. For use with propylene glycol, which is one of the most effective solvents, a special atomizer has been designed which is capable of producing sufficient volume of mist of the required particle size. The advantages of propylene glycol as solvent are that it increases the efficiency of the antiseptic and because of its non-volatility makes the antiseptic aerosol more persistent.

The antiseptics which so far have proved most effective are resorcinol, hexyl resorcinol, eugenol carbinol, sodium hypochlorite, allyl *p*-cresol carbinol, and catechol. Hexyl resorcinol and eugenol carbinol have the advantage of being almost imperceptible when present in the air in the concentrations in which they are required to be used. They differ in that eugenol carbinol kills rapidly but the activity disappears within half an hour, while hexyl resorcinol kills rather more slowly but has more persistent effect. Sodium hypo-

chlorite solutions are of particular value because of their characteristic and not unpleasant odour when present in the air in bactericidal concentrations, and because of their deodorizing properties. Unlike eugenol carbinol, resorcinols and propylene glycol, hypochlorites are readily obtainable in large quantities and at a low price.

Laboratory tests have shown that the antiseptics are effective in very low concentrations against bacteria sprayed from water or saline suspensions. A concentration of ½ to 1 grm. of hexyl resorcinol, for instance, is capable of destroying 95-99% of bacteria in 400,000 cu. ft. of air in ten minutes. The addition of organic material (broth or serum) to the medium in which the organisms for spraying are suspended greatly reduces the bactericidal power of the antiseptic. In experiments performed in a room of 800 cu. ft., using a constant amount of mist, organisms sprayed from broth require 100 times the concentration of antiseptic in the original solution for effective kill, than organisms sprayed from water. As is the case with ultra-violet light, dryness and the presence of large dust particles seriously interfere with the efficacy of the aerial antiseptics.

In experiments designed to approximate more closely to practical conditions use was made of ferrets infected with hæmolytic streptococci. Ferrets suffering from influenza are susceptible to infection with a hæmolytic streptococcus of Lancefield's Group C (R. E. Glover, personal communication). Such infected ferrets disseminate large numbers of streptococci into the air. Sprays of hypochlorite, hexyl resorcinol and eugenol carbinol have all been found capable, in tolerable concentrations, of causing significant reduction (70-80%) in the number of streptococci in the air of infected ferret cubicles.

These results suggest that germicidal sprays have a significant bactericidal effect on infected droplets. The presence of large numbers of dry and dust-borne bacteria, will, however, greatly reduce their efficacy. They would probably be most useful in operating theatres and small wards where adequate ventilation is impossible, especially when used in conjunction with methods designed to minimize the amount of dust present. In large wards it is unlikely that a sufficient concentration of antiseptic could be maintained, but it has been suggested that screening may assist in localizing the effect round individual beds when dressings are changed, &c.

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Dr. J. Trueta: While convinced of the important part bacteria play in the development of infections in wounds, I am even more convinced that the severity of the infections depends upon the local characteristics of the wound rather than upon the nature of the infecting organisms. I have had many cases in which the hæmolytic streptococcus and *B. welchii* were grown from the wound but gave rise to no disturbance in the process of healing; also I have seen many cases in a bad general condition with pain and temperature due to the pathogenic action of bacteria where improvement followed a simple surgical measure without the action of any antiseptic. After the patient had recovered the same bacteria were still found growing in the wound. This is not to say I regard the pathogenic bacteria as incapable of producing the most serious reactions in the body, and all precautions must be taken to keep them away from wounds; with this idea I employ the plaster technique. The objects are twofold: to prevent the entrance of bacteria that would normally occur whenever the dressings were changed, and to obtain the best conditions of rest and good circulation to allow the tissues to destroy the few remaining bacteria after the proper surgical cleaning of a fresh wound.

Air contamination may be important, but in the methods employed by the German school, Schade, Braun and Bohler, the limb is immobilized and the wound left exposed to the air. The satisfactory healing of the majority of these cases is sufficient evidence that air is a secondary factor in the production of infections in wounds. More important is the manipulation of the limb with the consequent increase in the lymph flow.

Dr. H. Loewenthal emphasized the advantages of using blood-agar plates containing 1% of glucose in the rapid diagnosis of *Cl. welchii* infections. When after overnight incubation in the anaerobic jar the plates are exposed to the air, the colonies of *Cl. welchii* show a characteristic change of colour from greyish-white first to strawberry colour and after a few hours to olive green. At the same time the highly characteristic smell of butyric acid develops.

Dr. W. R. Thrower said that Dr. van den Ende's remarks on possible methods of laying dust should bring comfort to the users of wet tea leaves for the same purpose in houses. In fact the advantages of a simple method with spindle oil or otherwise of keeping down air-borne infection had obvious practical applications, should further work support the promise of the initial findings.

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Section of Comparative Medicine

President—C. H. ANDREWES, M.D., F.R.S.

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DISCUSSION ON THE ÆTIOLOGY AND MORBID ANATOMY OF FOWL PARALYSIS (NEUROLYMPHOMATOSIS)

Mr. F. Blakemore (*Institute of Animal Pathology, Cambridge*).—Fowl paralysis has been the subject of many publications and there are still differences of opinion regarding its causation. It was first reported in this country by Galloway (1929), and McGaughey and Downie (1930) described the condition in detail and drew attention to its prevalence in certain parts of the country. Since then its recorded incidence has increased and it is now regarded as one of the most important diseases affecting poultry.

Fowl paralysis is characterized by thickening of the nerves due to infiltration of cells of the lymphocytic series between the fibres. In a high percentage of affected fowls collections of similar cells are also found in the organs and these lesions may assume a considerable size, being observed on post-mortem examination as diffuse infiltrations or tumour-like masses. While the classical symptom of the disease is paralysis this is not the only sign of the disease since sometimes there is marked iritis. Moreover, fowls are often unthrifty before the development of paralytic symptoms, and one of the most serious aspects of the disease is the loss of "flock-condition" and the retarded growth rate of the fowls. Many parasites are often found in the intestinal tract of the affected fowls and it was this association which gave rise to the theory, later disproved, that parasites were the cause of fowl paralysis.

The Transmission of the Disease

In early experiments (Blakemore and Glover, 1934) we succeeded in transmitting the disease to a number of fowls by the inoculation of suitable material, but the percentage of cases produced was not high. The experiments of Biely *et al.* (1933) and Dalling and Warrack (1933) indicated that certain strains of fowls may be relatively resistant to fowl paralysis, and so it was decided to repeat the work using a different strain of fowl. A full account of some of the work has been published (Blakemore, 1939).

At one time the strain used in the experiments was severely affected with fowl paralysis but by inbreeding and carefully isolating the progeny the disease was eliminated.

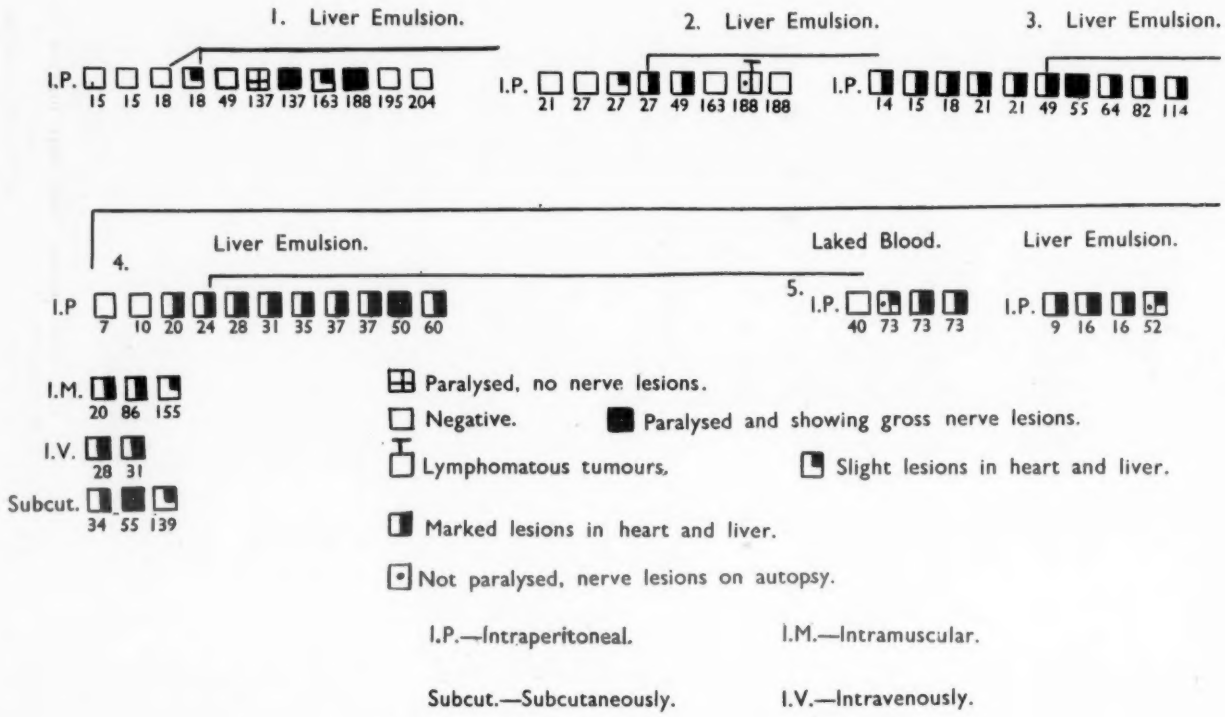
1. Liver Emulsion.
I.P. 15 15 18 18 49 137 137 163 188 195 204
2. Liver Emulsion.
I.P. 21 27 27 27 49 163 188 188
3. Liver Emulsion.
I.P. 14 15 18 21 21 49 55 64 82 114
4. Liver Emulsion.
I.P 7 10 20 24 28 31 35 37 37 50 60
5. Laked Blood.
I.P. 40 73 73 73
Liver Emulsion.
I.P. 9 16 16 52
I.M. 20 86 155
I.V. 28 31
Subcut. 34 55 139
Paralysed, no nerve lesions.
Negative.
Paralysed and showing gross nerve lesions.
Lymphomatous tumours.
Slight lesions in heart and liver.
Marked lesions in heart and liver.
Not paralysed, nerve lesions on autopsy.
I.P.—Intraperitoneal.
I.M.—Intramuscular.
Subcut.—Subcutaneously.
I.V.—Intravenously.
The numerals indicate days after injection when fowls were examined.

FIG. 1.—Passage experiments. (From " The Nature of Fowl Paralysis ", by F. Blakemore, *J. Comp. Path. & Therap.*, **52**, 144.)

Fowls of the fifth generation were mainly used for the experiments, the object of which was to test the susceptibility of young chickens by (1) the intraperitoneal injection of emulsions of nerves and other tissues (e.g. liver, spleen, &c.) of affected fowls and (2) contact with the naturally occurring disease. Judging by the occurrence of nerve lesions, fowl paralysis was transmitted to 23 of 78 injected chickens and 14 of 33 placed in contact with naturally affected fowls became infected; control chickens remained healthy. Further noteworthy features were the general unthriftiness and the occurrence of lymphomatous tumours in the injected and exposed groups.

During the transmission experiments lesions of a somewhat different type were observed in some of the visceral organs of the treated chickens, especially in the heart and liver. The pericardial sac usually contained a small amount of clear serous fluid and whitish areas were found in the myocardium and liver. The possibility was considered that this atypical response resulted from the inoculation of a second agent; in order to study its relationship to fowl paralysis, material from a case not showing nerve involvement was injected into a group of chickens and transmitted serially to four other groups (fig. 1). The infecting agent increased in virulence for by the fourth

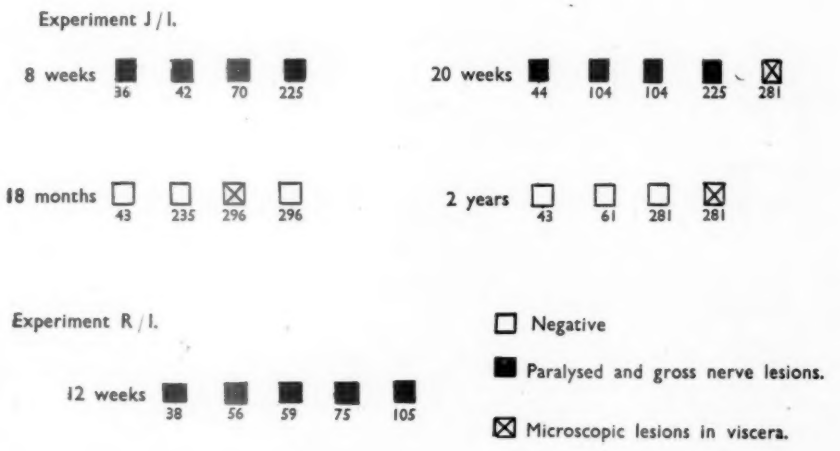

FIG. 2.—Inoculation of fowls of various ages.

passage 9 of 11 chickens died within thirty-two days of being injected. Some of the survivors of the acute disease became paralysed because of the development of neural lesions, and it was concluded that the tissue changes which were at first believed to be atypical really represented an early stage in the development of the lymphomatous process. Further experiments showed that the agent responsible was filtrable, and that the disease could be transmitted by intravenous and intramuscular injection as well as by the feeding of infective material.

Later, it was found that fowls over the age of 12 months were resistant to the infection (fig. 2). When large doses of material from acute passage cases were injected into 14 fowls varying in age between 2—5 months the results were striking. The fowls remained in good health but 13 of them developed paralytic symptoms from 36 to 225 days after injection. Marked nerve lesions were found on autopsy and there was also infiltra-

tion of the liver and heart in each case. This result afforded additional evidence that nerve lesions were a chronic manifestation of the disease with which we were dealing.

Pathology of the Experimental Disease

During the experiments it was possible to study the lesions in the acute and chronic phases of the disease. The passage chickens which died approximately ten days after inoculation showed focal necrosis of the liver and the cardiac fibres were similarly affected. Such changes could also be found to a less extent in the other parenchymatous organs. At this stage there was little cellular reaction in the liver, but in birds which survived the necrosed areas became infiltrated with cells and there were some fibroblasts and fibrillary tissue. At first, eosinophiles were abundant but later the areas became packed with lymphocytes and larger cells which resembled mammalian plasma cells. At the same time certain changes were apparent in the vessels ; the walls became thickened owing to proliferation of cells, principally in the adventitious layer. Activation of the endothelial linings was sometimes also seen, giving rise to cellular proliferation into the lumina of the vessels. While in acute cases the lesions were scattered diffusely throughout the whole liver, there was a tendency in the chronic disease for them to be localized and extensive areas of the organs appeared normal. Lymphocytic infiltration was a feature of even the early lesions, but many polymorphs and other cells were also present and the true lymphomatous response was seen most clearly in the fowls killed three months or more after injection. These lesions were seen as neoplastic areas and they appeared to have arisen from the perivascular infiltrations which are a feature of fowls' tissues.

In the myocardium the acute type of reaction was frankly inflammatory and there was usually an associated pericarditis. The cellular reaction often followed the course of the loose connective tissue between collections of the fibres but in the lymphomatous stage there was a tendency for the areas to be localized and well defined.

The changes in the nerves were typical of neurolymphomatosis, there being an early lymphocytic infiltration which was especially pronounced around the vessels. Later, large cells which have been mentioned in connexion with the visceral lesions made their appearance, and in very grossly thickened nerves they were the predominant cellular element. This transition in the cellular structure of nerve lesions is a constant feature of the disease and it is also well seen to a certain degree in lesions situated in other parts of the body.

Strain Susceptibility

Our success in producing such a high percentage of cases of fowl paralysis amongst the experimental fowls was largely attributed to the high susceptibility of the strain employed. It may be argued that the infective material stimulated a latent infection and though this possibility must be seriously considered the general trend of the results and the transitional stages observed in the lesions are against such a view. Moreover, in the original experiments chickens of another strain in which there was no history of fowl paralysis were injected concurrently with the same results.

In the course of our work on the agent in which we have been interested, we have been able to make observations on the susceptibility of other strains. This study is incomplete but it is evident that great differences exist between fowls of different origin. The position is further complicated by the fact that we have evidence that some fowls do not develop the lymphomatous type of response to any extent, although they may show evidence of the acute disease following injection. For instance, in the Cambar breed of fowls the agent produces a very severe disease, but the few survivors we have kept under observation have recovered and on post-mortem examination no lymphomatous deposits have been found.

Summary

A short account has been given of a number of experiments which showed that neurolymphomatosis could be stimulated by the inoculation of material from a field outbreak of the disease. We have since been able to study the disease on other farms in East Anglia and the same agent has been demonstrated in material from 7 of 11

flocks examined. We have also observed lesions of the kind described in the acute disease in young birds from three affected flocks and there seems little doubt that we are dealing with a widespread infection which is associated with neurolymphomatosis.

Clinically, the experimental disease closely resembles the more severe type of outbreak in which unthriftiness of the stock is an important factor. It is, however, well known that symptoms of neurolymphomatosis sometimes develop in fowls in good condition and although the incidence of the disease in such instances is usually not high, it must be admitted that the general features of such outbreaks differ from those of the experimental condition. In this connexion, however, it is interesting to note that the inoculation of more resistant strains of chickens has sometimes stimulated the development of marked early lesions without causing any disturbance of general health.

There is no essential difference between the histology of the lesions observed in our chronic disease and those described in field cases of neurolymphomatosis, but the tendency in our disease for the lymphomatous deposits to affect principally the heart and liver is of interest since Stubbs (1938) claims that the liver is rarely involved to any extent in the disease as it occurs in America. Indeed, he mentions the non-involvement of the liver as one of the principal differences between neurolymphomatosis and hepatolymphomatosis, the latter condition being regarded as a specific entity commonly called "big-liver disease". The position is further confused by the fact that Stubbs (1938) refers to the frequency with which lymphomatous lesions occur in the ovary, kidney, lung and heart in fowl paralysis. In this country the liver is frequently affected and it is difficult to understand why it should escape serious damage. Nevertheless, this difference in the gross pathology may indicate certain essential differences between the disease as it occurs in various parts of the world and may signify that lymphocytic infiltration of nerves may complicate a number of different but perhaps allied disease processes. The findings of Furth (1935) also seem to indicate that this may be so since he described several distinct transmissible conditions in which there was a tendency for cellular infiltrations to occur between the nerve fibres.

The early lesions described in our cases have not been mentioned by workers who have studied the pathology of fowl paralysis and the only account in the literature of a similar condition was published by Adamstone (1936). He referred to the disease as lymphoblastomatosis and asserted that its development in the chick was favoured by a deficiency of vitamin E. He did not describe nerve lesions in his cases but it would seem that they were not kept under observation for any great length of time. In view of Adamstone's findings we considered the vitamin E content of our rations; there was no evidence of a deficiency. It was only by exalting the virulence of the virus that we were able to demonstrate the early lesions, and the failure of other workers to find similar lesions may be due to the fact that all their pathological studies appear to have been concerned solely with material from fowls showing paralytic symptoms. Nevertheless, our observations are of special interest in view of the findings of Pappenheimer *et al.* (1929) and of Potel (1938). Pappenheimer and his co-workers observed in some of their cases lesions which were inflammatory in nature, and they concluded that this was evidence of transition between lesions which were frankly inflammatory and those which assumed the characters of a neoplasm. Potel regarded the disease as a form of fowl leukosis but he did not describe any leukæmic changes in the blood. His opinion was largely based on the detection in the lesions of cells which resembled lymphoblasts. In 11 cases showing visceral lesions Potel found the ovary, heart and liver to be the commonest sites of infiltration. In all the organs and the nerves he found signs of vascular involvement evidenced by activation of the endothelial cells and proliferation of the subendothelial and adventitious tissues, and claimed that the lymphocytes were derived from lymphoblasts situated around the vessels. This observation of vascular involvement is of particular interest when considering the association of our experimental disease and fowl paralysis, since the vessel walls are involved very early in the course of the experimental disease and show changes very similar to those described by Potel.

Patterson (1936) suggests that erythroleukosis, myeloid and lymphoid leukosis are all expressions of the same transmissible disease. In the course of our work we have been unable to confirm his findings and his results may have been due to spontaneous development of such cases amongst the experiment stock.

The relationship of fowl paralysis to leukæmia must be considered since the condition resembles Ellermann's lymphogenous leukæmia in that both conditions are characterized by the development of lesions and the absence of leukæmic changes in the blood. While it would seem impossible in the present state of our knowledge to attempt a classification of these diseases, it would seem that neurolymphomatosis represents a condition which has no parallel in mammalian pathology. Our observations indicate that in certain strains of fowls the lymphomatous response may follow infection with a filtrable virus which we have shown to be associated with several field outbreaks. We have some evidence, however, that the virus will not stimulate neurolymphomatosis in all fowls and a full inquiry into strain susceptibility is necessary in order to obtain information regarding the epidemiology of the disease.

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Mr. R. E. Glover pointed out that in the early work on fowl paralysis there was considerable doubt as to whether the disease should be regarded as purely neoplastic in origin or whether it should be considered as inflammatory in nature. Even now it was not possible to give a final opinion, since there were certain features, such as the production of lymphomatous growths in various parts of the body, which seemed to point to neoplasia whereas others were highly suggestive of an inflammatory condition. It would almost seem that neurolymphomatosis was an intermediate stage between these two types.

The experiments of Mr. Blakemore were most important and had served to clarify the position. There could now be no doubt that there were certain forms of neurolymphomatosis which were infective and regularly inoculable. It was obvious that many of the earlier failures to transmit the disease were due to the selection of experimental birds which were too old. Mr. Blakemore had shown that in the young chick it was possible to set up an acute infection which was readily transmissible in series. At first sight it did not bear much resemblance to field cases of fowl paralysis but a careful study of the liver and heart lesions in experimental birds and the subsequent recognition of identical changes in the same organs in natural cases, selected at a sufficiently early stage, showed that a similar sequence of events was taking place.

Mr. Glover had been able to confirm the observations of Mr. Blakemore, using material derived from a turkey affected with neurolymphomatosis (Andrewes and Glover, 1939). Characteristic lesions had been induced in young chicks with suspensions of liver and heart as well as with enlarged peripheral nerves. The disease had been passed through 16 generations. It was found that the lesions produced corresponded exactly with those described by Mr. Blakemore but only a relatively small number of the birds succumbed (11 out of 157). The explanation was probably dependent upon the use of different strains of experimental birds, the species available being of the Brown Leghorn (B.L.) and Plymouth Rock (P.R.) varieties. It was conceivable, of course, that the infective agent derived from the turkey was of lower virulence than fowl strains and produced lesions in chicks which were less severe. On the other hand, material obtained from Mr. Blakemore, as well as from a field outbreak of paralysis in fowls, when inoculated into experimental chicks (B.L. and P.R.) provoked a disease of the milder type. These findings tended to confirm the theory of Mr. Blakemore that there were differences in species

susceptibility to the virus. In nearly all cases lesions were seen in the myocardium and liver although their presence was not always visible by naked-eye inspection. Microscopical examination, however, revealed the characteristic necrotic foci with lymphocytic infiltration. Attention was drawn to the similarity in the sequence of events in the myocardium as compared with affected nerves. In both cases the earliest change was an œdematous infiltration between the muscle fibres and nerve fibres respectively followed by an infiltration with cells of the small lymphocytic variety, and later of the histiocytic type. The small cells in the initial stages were clustered round the vessels and were probably derived from the blood. The larger cells which appeared subsequently were more likely to arise from proliferation of the neurolemmal cells.

In experimental chicks the organs remained infective for long periods extending from the 12th to the 136th day, but evidence had been obtained that the agent was more potent or more abundant in the early lesions. Changes in nerves were found in only a proportion of the experimental chicks examined, while tumours were invariably absent. This difference between the experimental and natural disease was ascribed to the relatively short period of time the birds were kept, the period probably being insufficient to permit the development of neural lesions.

The infective agent which was filtrable, evoked particularly severe changes by the intravenous route. Infection was also secured after intramuscular, intranasal and intracerebral inoculation : in the latter instance no evidence of localization of the virus in the brain was detected. The agent was resistant to drying and was recovered from desiccated liver up to a period of 135 days (not end-point). Protective antibodies had not been detected in the sera of recovered birds (artificially infected) while formolized suspensions of infective liver failed to afford any protection against a test dose given one month later.

Dr. H. P. Bayon : A minor matter in Mr. Blakemore's work is whether a large and a smaller lymphoidal cell-type can be detected in the nerve lesions of the disease ; in my opinion, the difference in size is sometimes the outcome of shrinkage due to necrotic changes. This is not by way of criticism, but merely a suggestion in relation to microscopical diagnosis.

From the results achieved by both Mr. Blakemore and Mr. Glover, it is evident that there is a tendency for the " virus " to attack organs or tissues which are undergoing some form of stress ; the ovary when pullets are coming into lay or the nerves.

The separation of a lymphoidal tumour into a leucotic " virus " and one producing a fibrosarcoma of the Rous type has been described in the *Proceedings*, 1937, **30**, 377 (Sect. Path., 31).

Mr. C. A. McGaughey : Attempts to induce lesions in the chorio-allantoic membranes of developing chick embryo were unsuccessful but it was noted that in some cases the embryos died. In a further series of experiments, the material was inoculated directly into the allantoic sac or into the embryos. Using eggs from a strain of fowls susceptible to the agent, it was found that in many cases the embryo died after three, four or five days ; in other cases, the chicks hatched and developed symptoms similar to those shown by chicks inoculated when a few days old. On post-mortem examination, lesions similar to those described by Blakemore were found.

The inocula used included : Berkefeld V filtrates, Gradocol membrane filtrate and deposit obtained from filtrates by prolonged centrifugation in an Angle centrifuge.

When eggs from a strain of fowls shown to be resistant to the agent were used, no deaths in the embryo occurred and the chicks hatched from such eggs remained healthy.

Mr. L. E. Hughes : Fowl paralysis has been studied at Weybridge for some years. In the recorded results of many transmission experiments the incidence of the disease amongst the control birds has been high ; because of this two strains of fowls were selected for the work at Weybridge with a negative history of the disease. This work is still in progress, but the results obtained so far are in agreement with those of others, i.e. it is possible to transmit the disease in a relatively low percentage of cases. The incidence amongst the control birds has been almost completely negative. As a result of a visit to Cambridge attempts were made at the transmission of an acute form of the disease described by

Blakemore. This has been successful, but the number of positive cases obtained has been relatively small thus indicating that different strains of fowls differ in their susceptibility to inoculation with fowl paralysis material at an early age.

Attempts have been made to demonstrate the presence of antibodies in the blood of cases of the disease by means of complement-fixation tests, using as an antigen suspensions of enlarged nerves ground up in saline and also, such nerves extracted with alcohol. No circulating antibodies could be demonstrated.

Section of Laryngology

President—T. B. Layton, D.S.O., M.S.

[*December* 6, 1940]

DISCUSSION ON ASPECTS OF SINUSITIS

J. C. Hogg: *The treatment of chronic ethmoiditis by the transantral operation.*—The purpose of my contribution is to discuss a series of cases of chronic ethmoiditis which have been treated surgically by the transantral route. All presented signs of severe sinusitis, characterized by purulent discharge and polypoid degeneration of the mucous membrane in the middle meatus of the nose. It is not claimed that the mere presence of ethmoiditis is of itself an indication for radical surgical measures, for it is common experience in every clinic that many patients with gross disease can be kept comfortable and in reasonable health by simple removal of polypi in the out-patient department. It is salutary also to recollect the saying of Ross Skillern (1921), that radical sinus operations by no means always end in radical cures. Yet there remain the large number of patients, particularly in hospital practice, whose symptoms of headache or general toxæmia do not yield to these minor measures and in whom more extensive operative treatment is required. For the relief of this type of sinusitis the choice lies between an intranasal operation and one of the extranasal procedures, the approach passing either through the skin internal to the inner canthus of the eye or through the postero-superior angle of the antrum, the transantral route. In my hands intranasal surgery has frequently proved disappointing, recurrence taking place in a high proportion of cases, necessitating a further operation, or all too frequently, a series of operations, not altogether free from risk of damage to the cribriform plate owing to loss of accurate anatomical landmarks. The introitus nasi, formed by the pyriform aperture, is inelastic and is situated on a plane internal to the ethmoidal cells, thereby seriously restricting vision in a very vascular operative field. This is so much so that the operator is driven to rely largely on his sense of touch, which can hardly lead to the precision of technique necessary for success. It is notoriously difficult to achieve complete exenteration of the ethmoidal cells even by an external operation under full vision, and since success depends on completeness I have largely abandoned intranasal methods in favour of the transantral operation. Undoubtedly, the external operation through the skin of the face gives the most adequate access, but in spite of the good cosmetic results which can generally be obtained it is extremely difficult to persuade patients to submit to this type of operation.

The transantral operation was originally described by Jansen in 1894. Boenninghaus (1913) also stated that the posterior sinuses may readily be opened on their lateral aspect during the course of a radical antrum operation, but Hajek maintained that excessive bleeding was likely to ensue. A notable advocate of this approach to the ethmoid has been J. B. Horgan of Cork (1926), whose paper gave excellent anatomical reasons for preferring the transantral to the intranasal operation. It was after being privileged to watch Horgan operate in 1934 that my interest in this technique was stimulated, as it promised the means of dealing adequately at one session with the ethmoidal disease and the concomitant infection in the antrum and sphenoidal sinus. For it is my belief that the continuity of infection in chronic sinus disease and the close anatomical relationship between the ostia lead eventually to an inevitable infection of all the cells, with the possible exception of the frontal sinus, which is protected to some extent by its relatively isolated position and by the length of the fronto-nasal duct.

Many of the failures of intranasal operations can be traced to residual infection in the antrum leading to rapid recurrence of polypi in the nose. Too often a negative result from antrum puncture and lavage is taken as proof that the antrum is free from disease, whereas it may be almost entirely filled with polypi, as can be demonstrated at operation through the canine fossa. In my experience simple drainage, with or without lavage, gives very poor results in the form of sinusitis accompanied by polypoid changes, in marked contrast to the pure antral empyema, where the results of drainage are usually brilliant. What has been said of the antrum I have found to be true of the sphenoidal sinus as well, although here perhaps I am on more controversial ground. But where the ethmoidal cells are grossly involved I have never failed to find similar changes in the sphenoidal sinus, and failure to open this important cell is liable to lead to post-operative complications such as secondary hæmorrhage or acute otitis media. At a later stage a recurrence of polypi or a crusting discharge can also be traced to the same source. Post-operative crusting, provided that care is taken to exclude from operation all cases showing atrophic changes, is a signal for further search for infected cells which have been missed during the operation. Crusting does not arise merely from loss of tissue alone.

The transantral operation is best performed under general anæsthesia, for it is difficult to secure adequate local anæsthesia in the face of severe nasal sepsis. The Caldwell-Luc operation is performed, care being taken to extend the opening in the bone well upwards and inwards. Denker's operation was tried in a small series of cases, but it was discontinued as it was found that there was a tendency for the soft tissues to fall in and to block the infraturbinal opening into the antrum. The mucous membrane of the antrum is stripped out and the infraturbinal opening is made in the usual way. To open into the posterior ethmoidal cells the closed blades of Luc's forceps may be pushed through the upper, inner and posterior angle of the antrum, experience making it easy to select the best spot. The ethmoidal system having been entered on its undersurface, the cells may be systematically ablated backwards to the sphenoid, forwards to the frontal process of the maxilla and inwards to the upper attachment of the middle turbinate. This can almost always be done under full vision, with reasonable safety, since the roof formed by the orbital plate of the frontal bone is of considerable strength, while the cribriform plate is protected by the middle turbinate. Laterally the thin lamina papyracea may occasionally be fractured, but no untoward results have been observed other than transient bruising of the eyelids. Should there be difficulty in stripping away tags of adherent mucous membrane the 5% picric acid in 35% acetone solution on pledglets of gauze, as recommended by Ferris Smith, is of valuable assistance. The sphenoidal sinus is next entered by removal of its front wall down to the thicker bone forming its floor. Unless skiagrams have demonstrated the presence of an unusually large sphenoidal sinus or of a pterygoid extension the mucous membrane is removed, but where such an extension is present it is my custom not to interfere with the mucosa, as I have found that partial removal is prone to lead subsequently to pocket formation. At this stage the middle turbinate is removed by means of nasal scissors and a snare. Occasionally it is possible to leave the middle turbinate in situ, as advocated by Horgan, but in most cases the polypoid changes in this severe type of sinusitis make turbinectomy advisable. Where, however, careful inspection fails to reveal any disease in the turbinate it should be preserved, with great advantage to the physiology of the nose, since it serves a valuable purpose in assisting the inferior turbinate to warm, moisten and sterilize the inspired air. It is striking how normal the nasal cavity may look some months after the operation. Jansen, in his original paper, recommended the complete removal of the turbinate-bearing area, a procedure which has also been advocated by Bedford Russell (1939) under the term "cavitation". In view of the valuable properties of the inferior turbinate in keeping moist the mucous membrane of the nose and pharynx, every effort should be made to preserve this structure by contenting oneself with the removal of any hypertrophies which interfere with proper ventilation of the nose. As Graham Brown (1939) has pointed out, as long as its anterior and posterior attachments are not interfered with it will preserve its vitality in spite of almost total removal of the rest of the antro-nasal wall. After-treatment consists in gentle irrigation of the nose and antral cavity on the fifth day to assist in expulsion of clots or crusts. During the process of healing some crusting is inevitable, and the operator will assist in keeping the patient comfortable by removing the crusts two or three times a week. Pain is not usually severe, unless undue stretching or other damage to the infra-orbital nerve has taken place. Treatment by short-wave

radiation is comforting and seems to have accelerated the healing process in several cases.

In all, 132 cases of sinusitis have been subjected to the transantral operation. Of these 14 are too recent and will not be considered in this series. Of the remaining 118, 12 are untraced, leaving 106 cases which have been inspected on one or more occasions at least twelve months after the operation. In 49 or 46·1% of the cases under review a bilateral operation has been done. Of the 106 cases followed up 63 or 59·4% were found to have healed clean noses with consequent relief of their nasal symptoms. In 28 or 26·4% residual infection was still present, generally in the fronto-ethmoidal region, necessitating occasional visits to hospital for minor procedures such as removal of a polypus. All 28 cases were practically symptom-free and in no case was a further operation considered advisable. In 7 cases, or 6·6%, frontal sinusitis did not resolve in spite of the ethmoidal clearance. External operation according to Howarth or Ferris Smith was performed, but in 3 cases the frontal sinus had subsequently to be obliterated to obtain complete relief. The other 4 remain well. In 8 cases, or 7·5%, difficulty has been encountered owing to stenosis of the enlarged sphenoidal ostium. In spite of repeated wide openings there has been rapid contraction leaving a small ostium from which pus escapes with difficulty. I believe that this is more likely to occur in the presence of pre-existing osteitis, which leads to the formation of an annular ring of infected scar tissue. As elsewhere in the body, an annular stricture once formed is difficult to control, short of complete excision, and I have not yet found any satisfactory answer to the problem. In one case a Thiersch graft was applied to the raw edge of the sphenoidal opening on a small inflatable rubber balloon. It was certainly efficacious in keeping the ostium open, but has led to such persistent crusting that no further cases have been treated in this way. I am inclined to agree with Bedford Russell that squamous epithelium transplanted into the nose is unsatisfactory, except perhaps high up in the fronto-nasal duct as in Ferris Smith's operation.

In 13 cases, or 12·3%, otitis media occurred as a post-operative complication. A cortical mastoid operation became necessary in 3 patients, in 1 case on both ears. There were no fatal cases.

From the experience gained during the past seven years I have come to the conclusion that for these well-established cases of ethmoiditis the transantral operation offers a fair prospect of a lasting cure and that it possesses many advantages, both to the patient and the surgeon, in the management of severe chronic sinusitis.

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S. E. Birdsall said that he had performed operations similar to the one just described in about 50 cases, most of which were suffering from advanced ethmoiditis with polypi. The majority also had had previously numerous intranasal operations or simple removal of polypi. A radical operation might be the only operative procedure left with any rational hope of success, in which case the problem to decide was whether further surgery should be done or not. But it must also be considered whether it might be justifiable to perform a radical operation as an initial measure when the disease was first observed. He thought the frequently disappointing results of conservative surgery in ethmoiditis should lead them to consider more radical operations in the first instance. Chronic infection could seldom be cured by a mere drainage operation. If analogies were taken with other parts of the body, whereas an acute empyema of the pleural cavity or the gall-bladder would respond to aspiration or closed drainage, a chronic empyema would never be cured by a simple drainage operation. Suppuration in a nasal sinus was not an abscess but an empyema, and mere drainage of the pus from it was of no value unless the pus was in tension as it seldom was in chronic disease. The only course was to extirpate the infected tissue.

He could not modify or add to what Mr. Hogg had said concerning technique, except in regard to anæsthesia. In the last three cases on which he had operated local anæsthesia had been used with encouraging results. In these cases he had been much impressed

by the facility with which it was possible to follow every step of the operation. The hæmorrhage was much less and the view of the ethmoid cells was much better than could ever be obtained under general anæsthesia. With general anæsthesia the actual visual inspection of the ethmoid cells was at best rather momentary, but under local anæsthesia it was possible to view a large part of the ethmoid labyrinth and to see the swollen lining membrane of the cells and the honeycomb arrangement.

He had found the most sensitive area to be the region of the natural ostium into the antrum, and having discovered this, in subsequent cases he infiltrated with novocain through the antrum around the ostium, waiting a few minutes before doing the operation on the ethmoids, which then could be done without any pain.

A certain amount of crust formation was common during six weeks after the operation, but after this it ceased. The crusting was not due to too radical surgery, but more often to too little surgery or badly planned surgery. There must be pus formation before crust formation, but crusts could not be formed from healthy tissue nor merely from traumatized tissue. If pus were being produced and the mechanism for removing the secretions by the ciliary epithelium were absent, then crusts would appear.

One case which illustrated this point was that of a woman aged 46, who, when first seen by the speaker, had had nasal operations since 1918, that is, for twenty years. During the last three years she had been treated as a case of atrophic rhinitis. It was necessary to pack both nasal cavities. Crusts were still forming when he saw her, and she had bad headaches. On washing out the antrum he found a large amount of pus, so he operated on her, doing first the Caldwell-Luc operation. After removing all the infected tissue the nose consisted of a large cavity with a septum down the middle. There was no remnant of any turbinates whatever when he operated. At the present time, although she was far from being in a satisfactory state, there was no crusting. She had a dry pharyngitis, which was not surprising. The offensive odour had gone, and her mental condition, which was very poor, was improving.

Crusting might be attributed to too radical surgery, but in this case it was overcome by carrying the surgery a step further. In all his cases it had been necessary to remove the middle turbinate. The inferior turbinate he usually left alone without removing any part of it whatever, but in a few cases it was extremely difficult to wash out the cavity afterwards, and the house surgeon or the ward sister complained of the difficulty of getting the cannula underneath the inferior turbinate. In those cases he removed a small portion from the middle part of the inferior turbinate, and he did not think the removal of that small portion could lead to any bad effect.

W. I. Daggett said that it was generally accepted that there were three methods of approaching the ethmoid region, namely: (1) intranasal, (2) transantral, and (3) external. He had been much disappointed with the intranasal approach, and other surgeons had been equally disappointed. Even though the antrum was efficiently opened intranasally, intranasal operation on the ethmoid was in only too many cases unsatisfactory. This failure was more likely to be due to inefficient removal of infected ethmoidal cells than to anything else. He thought it quite natural that there should be many failures from such an operation because the field was very cramped and visibility was poor, particularly when the intranasal operation was done under a general anæsthetic.

He was quite satisfied that the antral lining need not necessarily be removed, and therefore he advocated the external operation, with which he had had excellent results. He did not mind having to do a Caldwell-Luc operation later.

This external operation was easy to carry out, and comparatively bloodless, at least as compared with many nasal operations. Particularly was this so if the operation area was first injected with novocain. He injected the soft tissues, and always made a point of putting the needle down outside the orbital periosteum and between that and the bone, and injecting a considerable amount of novocain.

Through this operative approach there was an excellent view of the ethmoid labyrinth, which could be widely removed, also an excellent view of the sphenoidal sinus, and at the same time—what was extremely important—the frontal sinus could be reached. In these cases he adopted the technique of Mr. Howarth, and having opened the frontal sinus into the nose, he removed the affected ethmoidal cells and drained the sphenoidal sinus. He skin-grafted on to the orbital periosteum, and continued this graft round the anterior aspect of the reconstructed fronto-nasal duct.

Mr. Hogg had said that he was disappointed to find that crusting followed grafting. For his own part he could not think of any of his cases which had had crusting after a period of six months, although, of course, he had lost sight of a certain number. Still, it was his opinion that crusting did not occur. Against this operation was the difficulty of persuading patients to have it done. Care must be taken in explaining its purpose to them. Many patients had fears of subsequent scarring, and it was a good thing to show them photographs to prove that there was singularly little scarring. He himself had been lucky in that he had never had any case of keloid in the scar.

It had fallen to his lot to see patients who had been treated in the United States for this type of ethmoiditis, and some of the results were remarkably good. But one thing that had struck him in many of these patients was that the nose had been treated in several stages. He did not mean that they had had a few polypi taken out, and again a few some months later. He meant that they had had a deflected septum put straight, and then, when the nose was wider and cleaner, they had had the ethmoid cleared. It was very important to straighten a badly deflected septum. It had always been taught that it was bad surgery to resect the nasal septum in the presence of sepsis, but from time to time he had been driven to do it, and he had never found the results any different from those experienced when operating on a clean nose. It was more important to straighten the septum before treating the chronic ethmoiditis than to do so afterwards.

He had not had any personal experience of the transnasal approach to the ethmoid. He had seen it done, and had tried it on the cadaver. He thought that there was more bleeding than by the external method, particularly if in the latter method the injection of novocain was employed. It seemed to him that it was more difficult to approach the sphenoidal sinus by the transantral method than it was by the external route. In his view, whenever the frontal sinus was affected the only efficient approach was by the external route.

The President said that there were two kinds of sinusitis, one which produced a purulent reaction, and the other which produced a polypoid reaction. As Mr. Hogg had said, drainage was the mark of success in the first, the pyogenic reaction, and quite useless in the second, which was now under discussion.

To touch on a point of technique for a moment, Mr. Hogg had said that it was difficult to secure complete local anæsthesia. This was because Mr. Hogg had not learned the technique of blocking the second division of the 5th nerve. Since he himself was a throat dresser both general and local anæsthesia had improved out of all recognition, and either method might be used, but no one was entitled to say that the other method did not give an anæsthesia.

With regard to the polypoid reaction, to what extent did the mere pulling of polypi out of the nose cure the disease in its early stages? Were there two distinct types of disease, one in which there were just one or two polypi and the other in which there was a diffuse polypoid reaction over the whole or a large part of the mucosa of the various sinuses?

He had expressed to Sir Charters Symonds, who founded the Throat Department at Guy's, his profound depression at the treatment of polypoid disease and at the failure to get a cure from the mere removal of polypi. Sir Charters had not at all agreed with that view, and said that it was a question of removing all the polypi efficiently at the first sitting. During the last year or so he had employed a new method of removing polypi. Instead of painting with cocaine inside the nose he had blocked the second division of the 5th nerve. With that, and with no other anæsthesia, the polypi could be removed from under the middle turbinal with far greater efficiency. Incidentally, Mr. F. J. Steward used to teach them that the great key to the painting procedure was to wait for three-quarters of an hour after painting before starting to remove the polypi. He was also taught in his younger days that the bit of bone which was the medial wall of the corresponding ethmoidal cell and to which the polyp was attached should be removed with the polypus.

He wished to focus the discussion on the question whether there were two stages of the disease, and whether when there were one or two or three polypi it was a curable disease, or whether from the very first it was not a curable disease by the intranasal operation.

There were various other points he would like to hear discussed, particularly with regard to this question of the sphenoidal and frontal sinuses. Sometimes it was urged that

it was essential to operate on the frontal when one had operated on the ethmoid, sometimes that it was essential to operate on the sphenoid, and sometimes that it was essential to operate on both. It almost seemed to him that the surgeon who found one of them essential was the one who liked the route which gave him access to that cell.

Walter Howarth said that there were two types of sinusitis amenable to treatment, one of which could be treated by the intranasal method, and the other, a more advanced type, in which the intranasal operation had not been done or had been a failure. Undoubtedly in a large number of cases of sinusitis successful results were obtainable by the intranasal method, and here he desired to traverse Mr. Birdsall's analogy between the frontal sinus and empyema in the gall-bladder. The gall-bladder was situated far back in the abdominal cavity and with a narrow exit on to the abdominal wall so that it was difficult to drain. On the other hand, in a frontal cavity, if the anterior ethmoidal cells were adequately removed, perfect drainage could be obtained. He thought they ought not to accept too readily the analogy of the gall-bladder and empyema.

He would go a little further and say that he thought that often the sinus that had a polypoid musosa, provided the drainage was adequate, would recover in certain cases. It was remarkable what capacity for recovery it showed, and that was now known to be true of the middle ear as well. A great many people now found that if the middle ear were drained properly by a modified radical mastoid operation it would settle down, whereas previously it had been thought to be hopeless and a radical operation required.

The intranasal operation was often a failure for the cure of this extensive suppuration, but that was probably so because the orbito-ethmoidal cells were not adequately removed, so that there was an ascending infection from those cells which kept up the suppuration in the cavity above. He was afraid that his own experience of the transantral operation was very limited so that he was not in a position to say much about it. When Mr. Horgan first introduced it he had tried it, and again more recently. He had found it give quite a good view of the posterior ethmoidal and sphenoidal region, but he could not reach the anterior cells or the fronto-nasal duct, and he gave it up for that reason. In his experience the anterior part of the ethmoid seemed to be much more frequently diseased than the posterior.

He agreed with Mr. Daggett that the external ethmoidal operation gave a most admirable approach to the anterior cell system. It enabled the surgeon to deal, practically bloodlessly if novocain were used, with the important orbito-ethmoidal and fronto-ethmoidal cells. If the incision was made in the delicate tissues near the inner canthus there remained a scar which was almost invisible. He could not, however, compare the two operations because his experience of the transantral one was not sufficient.

He was still against taking more than was necessary of the lining membrane. The polypi must be removed, but there was always something which could be left behind; in a large number of cases it was not as bad as it looked and the mucous membrane recovered to a considerable extent.

Bedford Russell said that one serious criticism of the transantral approach to the other sinuses was that it was inadequate in scope. He agreed with Mr. Howarth that one could not reach an orbito-ethmoidal or fronto-ethmoidal cell by this route. He regarded the majority of cases of sinusitis as having begun by a *diffuse* inflammation, as a result of such disorders as influenza and whooping-cough, followed very often by a hæmolytic streptococcal infection; and it would be remarkable if all the sinuses were not "tarred with the same brush" when symptoms of chronic sinusitis arose later in life. It was unlikely that one sinus only would be affected, except in the case of an antral infection of dental origin. Therefore, in bad cases he had been forced into dealing with *all* the sinuses on the same side, preferably at one sitting, or at most at two sittings, using an external approach combined with the transantral.

He used cavitation rarely—he would say in not more than one in twenty cases—but when it had to be used, it was very satisfactory. He used it for very bad cases, particularly those which were limited to the narrow side of a nose in which there was gross deflection of the septum. A septum operation added to an ethmoidal operation involved the risk of impairing the sense of smell; therefore he left the septum alone, and resected the turbinates, which gave access and a good airway, and did not, by the way, cause atrophic rhinitis. His criticism, therefore, of the transantral operation was that it was inadequate in the type of case which called for radical measures. There was nearly always a frontal

sinusitis in existence as well, which sooner or later, sometimes very soon, would otherwise declare itself.

He ventured to criticize Mr. Howarth's suggestion that one could determine which part of the mucous membrane of a given sinus was guilty and which part was innocent. Rhinologists, as Ferris Smith had remarked, were not endowed with microscopic vision, and it must be rare indeed to find that one part of the sinus was diseased and the other part healthy, in view of the lymphatic continuity between them. He would even say that it was impossible.

The President had asked how Mr. Russell determined that the patient was obviously suffering from pan-sinusitis, as he himself found it difficult to determine that all the cells were involved as distinct from two or three when something more than the maxillary sinus was concerned. In reply, Mr. Russell said that the results of attacking one sinus alone were often discouraging, and he had had to find out by experience when other sinuses were involved. When one sinus was affected (unless in dental cases) there was no such thing as complete freedom from disease on the part of all the other sinuses on that side, although the infection in the various sinuses usually "ripened" at different times. Diagnosis was assisted by X-rays, also by a measure not often enough employed, namely the removal of a piece of mucous membrane from near the ostium of a suspected sinus and its microscopical and bacteriological examination. Sometimes it was possible to grow a hæmolytic streptococcus from the submucosal layers. He had had this type of examination done by various pathological colleagues, and it was a "true bill". One guide to the existence of pan-sinusitis was the length of time over which the symptoms had persisted, coupled with the history of onset of the whole of the trouble. He regarded it as of great importance to determine the time of the acute infection, e.g. the 1918 influenza epidemic, which might have been the starting point of the symptoms.

D. F. A. Neilson asked whether a cure could be obtained by simply removing polypi in the early stages at one sitting. He had himself occasionally removed a few polypi from a patient and they had never seemed to recur. On the other hand, one often saw a patient with one or both sides of the nose crowded with polypi and in such a case he would say that all the ethmoidal cells, or at any rate some of them, were also affected with polypi.

Probably a sinus mucous membrane could be thickened to a pronounced extent without macroscopic evidence of it, but there was obvious microscopical evidence, and there was a great deal to be said for removing a piece of tissue for microscopical examination in many of these cases.

He agreed with what the President had said about anæsthesia. It was possible under general anæsthesia to get as bloodless a field of operation nowadays as under local. He always used general anæsthesia for preference because the patient usually preferred it and he could invariably get hold of an efficient anæsthetist in London.

Another question was to what extent all sinus disease could be avoided if patients with nasal infections were treated in the early stages. In such circumstances chronic nasal infection very rarely supervened. He had seen nasal polypi develop in a very short time, ten days or so. In cases seen early he believed in trying the less radical treatment, such as aspirating an antrum or a frontal sinus and removing the polypi. But radical surgery had to be done at times and he did not find that it resulted in crusting if it was carried out completely. He had seen, however, patients on whom such operations appeared to have been done efficiently complain of persistent attacks of pain.

S. E. Birdsall said that on the question of crusting, the point he had tried to make was that the crusting after radical surgery was usually attributed to the removal of too much tissue, thus suggesting that the pathology of the crusting was the same as in cases of atrophic rhinitis, and he had wished to emphasize his opinion that this was not so. In his view the crusting was not due to lack of tissue but to the persistence of suppuration in these cases. His analogy with disease in the abdomen had been criticized. The principle of treatment of infection was quite different when the infection was acute from what it was when the infection was chronic. No analogy in anatomy could be exact, but he thought there would be general agreement with him that an acute suppurative inflammation, whether in the maxillary antrum or the frontal sinus or in the gall-bladder or the pleural cavity, responded very well indeed to a drainage operation. He thought it was also correct to say that chronic infection in the four anatomical regions just named

was treated unsatisfactorily by drainage, although there were anatomical differences which naturally affected the picture. No case of chronic empyema, to his mind, ever improved by drainage. Some operation was required in order to deal with the infected lining if a good result was to be brought about.

J. C. Hogg (in reply) took up Mr. Daggett's point about the sphenoidal sinus. He did not always remove the lining. If he had reason to believe that the sphenoidal sinus was a large cavity or had an extension making it difficult to obtain good access to it, he left the mucous membrane alone because he found that after an incomplete attempt to remove it a large polypoid growth was likely to appear in the sphenoidal sinus within a few weeks.

There was little doubt that many of these cases had an allergic basis in the first instance, but by the time they were seen they had become infected elsewhere and demanded radical surgery, so that the question of allergy became a subsidiary one which could be taken up after the operation had been carried out.

Mr. Bedford Russell now considered that the frontal sinus should be included at the same time if possible. The present speaker had not found this necessary. His own view was that the case might be given a chance to settle down after as complete a resection as was possible by the transantral route. He had no hesitation in approaching through the nose rather than the antrum if occasion demanded it ; nevertheless, he thought that nine-tenths of the work in the ethmoidal cells could be done by way of the antrum, and this afforded a much better exposure, allowing binocular as against monocular vision. The operation seemed to him not only safer but more rational. No speaker had taken up the point about the sphenoidal sinuses which stenosed after opening. He still did not know how that occurrence could be prevented.

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President—J. ALISON GLOVER, O.B.E., M.D.

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DISCUSSION ON HYGIENE IN AIR-RAID SHELTERS

The Problem of the Air-Raid Shelter.

By P. G. STOCK, C.B., C.B.E., F.R.C.P., (Hon.) F.R.C.S.Ed.

BEFORE the collapse of France last summer it was hardly anticipated that shelters would be used as dormitories and the Government's shelter policy was that domestic shelter should be provided free of cost at the homes of those who could not be expected to provide it for themselves and that public shelter should be provided for persons caught in the street and for others for whom shelter could not be provided at their homes.

With the intensification of the air attack upon this country and particularly with the continuous night raids upon London it was found that shelters which were not originally designed for sleeping were being used as dormitories. Moreover, in some areas there was a tendency for the owner of the domestic shelter (such as the Anderson and brick surface shelter) to forsake it for the communal shelter, and personal fancies led to considerable nightly migrations from area to area. There was a rush to the underground tubes, indeed, the herd instinct asserted itself with the desire for human companionship in the face of danger and this rapidly led to the crux of the problem—large aggregations of people and overcrowding. Ostrich-like, people felt safer when they no longer heard the sound of gun-fire or exploding bombs. This feeling made them shun the surface shelter and seek protection underground or under railway arches, many of which were traditional from the last war. In many cases these had never been scheduled as shelters, and a number of them unfortunately afforded protection well below the official standard, more particularly in respect of the calamity risk.

As soon as it became apparent that a serious public health problem had arisen, the Minister of Home Security and the Minister of Health appointed a committee, under the chairmanship of Lord Horder, to inquire into the conditions of air-raid shelters, with particular reference to health. On September 25 the Chief Medical Officer of the Ministry of Health wrote to the medical officers of health of the metropolitan boroughs, asking them to carry out inspections of the public air-raid shelters in their areas. By the middle of October, when three medical officers of the Ministry were detailed to inspect shelters, very little improvement had been effected in the sanitary conditions in the shelters.

Apparently there were two main reasons for this, viz.: (1) The reluctance of many public health departments of the local authorities to enter a field from which they had previously been excluded; and (2) the fact that in practice the execution of the recommendations of the health department depended mainly upon the borough engineers'

departments, which usually were overwhelmed with other work, including the primary necessity of rendering the shelters structurally safe against bombing and the restoration of damaged public services. Moreover, there were shortages both of materials and labour and even under favourable conditions time was needed to convert shelters, which had never been designed for the purpose, into dormitories, suitable for the sheltering population. Additional medical officers of the Ministry were, therefore, detailed to visit shelters and co-operate with the local authorities.

Fundamentally the problem was that of overcrowding, with its attendant evils—insufficient closet accommodation, defective ventilation and lack of cleanliness. That many of the shelters were below the level of the sewers made recourse to pail closets, with all the accompanying difficulties, essential. Another serious defect was dampness, due to faulty roofing, to the flooding of the entrance by storm water or to condensation of moisture on the walls, and in some shelters to all three. In wet weather the dampness led to increased overcrowding in those shelters or parts of shelters which remained dry.

Apart from the underground tube stations, lighting was often inadequate or badly placed, whilst in very few shelters were there arrangements for effective lighting during the evening and dimmed lighting during the night. There was often no heating arrangement—a problem which bristles with difficulties and is closely related with questions of ventilation.

Two other points only will be mentioned, viz. : (*a*) The absence of a piped water supply in many large shelters (and, where available, the absence of adequate arrangements for preventing the accumulation of damp around the taps) ; and (*b*) the mosquito nuisance in several tube stations.

To overcome these difficulties various circulars have been issued by the Ministry of Health and large financial obligations assumed by the Government. For instance, in order to secure the regular medical supervision of shelters the appointment of additional assistants to medical officers of health has been authorized at the cost of the Exchequer. Ministerial broadcasts, statements in the Press and instructions to the Regions have been directed to secure the utmost degree of dispersal so as to deal with the crux of the problem —overcrowding.

To illustrate the attitude of the Ministry it is only right to tell you of the very great personal interest which the Minister himself takes in this problem. However tiring the day or dirty the night nothing will prevent Mr. Malcolm MacDonald and the higher officials of the department from visiting shelters three or four nights a week in order to see the conditions for themselves.

Perhaps children may be expected to suffer most from the conditions of "shelter life" and everything possible has been done to secure their voluntary evacuation to the comparative safety of the countryside. Mothers accompanied by their children, expectant mothers and the aged, crippled and infirm are also included in the Government scheme of evacuation.

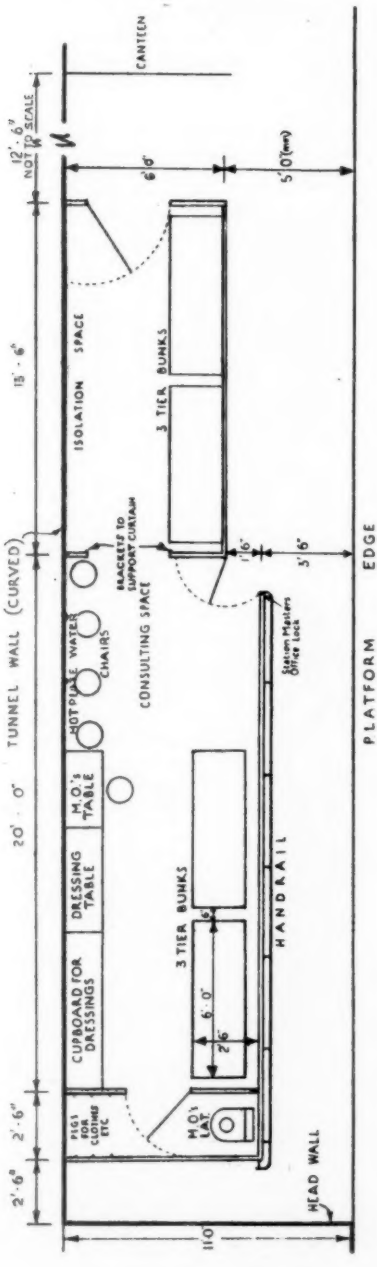
A ticket system for the habitual users of shelters has also been introduced and is generally being enforced as the shelters are provided with bunks for sleeping purposes.

A re-survey has also been made with a view to finding further shelter accommodation, and much additional accommodation has already been secured, whilst a long-term policy of additional tunnels has also been undertaken.

In spite of these efforts, a degree of overcrowding still exists in many shelters which no health officer can regard with equanimity.

The most urgent part of the shelter problem is the need to find adequate protection for the people at once. The Horder Committee urged that full use should be made of whatever means of ventilation exist, and early in October an authoritative committee was appointed under Sir Alexander Rouse to consider ventilation and heating. As a result the policy of rendering shelters gas-tight has been abandoned, curtains abolished, shafts previously closed have been opened up, and where practicable fans have been installed. After considerable hesitation it has been decided to install coal-burning stoves for use in public surface shelters holding 50 or more persons in one compartment and in trenches. Experiments are also being carried out in electric heating, but the supply question at present renders this impracticable for the majority of shelters.

The employment of medical practitioners and nurses for attendance at shelters has been



PLAN FOR A MEDICAL AID POST
AT AN
UNDERGROUND TUBE STATION

$\frac{1}{8}$" = 1'

authorized, but obviously it is in the larger shelters that outbreaks of disease are mostly to be feared. In shelters, therefore, whose nightly population is some 500 people or more, local authorities have been asked to establish medical aid posts, the equipment being provided by the Ministry of Health : in fact, the whole of the cost is borne by the Exchequer.

The plan, p. 3, indicates the type of medical aid post which has been installed in the tube shelters.

It may perhaps be aptly described as a forward " observation post " in the battle against disease in the shelters.

The primary purpose of the medical aid post is to facilitate the early detection of cases of infectious disease, which must be isolated forthwith, and to provide for cases of accident or acute illness which may arise in the shelter. As a rule, only cases of minor illness or accident should be retained for the night in the post and, dependent on the degree of enemy activity at the time, serious cases, including cases of infectious disease, should be removed to hospital. It would be wearisome to recapitulate all the measures to be taken to prevent the spread of infection among those using public air-raid shelters. These risks will be most effectively met by preventive measures among the population. The incidence of diphtheria may be increased as the result of shelter conditions and the importance of encouraging artificial immunization of children free of cost has been urged.

The work which has been done at the National Institute for Medical Research goes to show that the risks of air-borne infection may be reduced by spraying the atmosphere of shelters, and the Horder Committee have recommended the use of sodium hypochlorite in aqueous solution on account of its procurability, cheapness and intrinsic merits as an antiseptic.

The Ministry of Health are anxious to have the proposals of the National Institute for Medical Research put into practice as quickly as possible, and orders have been placed for two types of apparatus which will be issued to local authorities as deliveries are made. Thanks to the help of Mr. Thomas and the ready co-operation of the London Passenger Transport Board, a large-scale trial—under the supervision of Mr. Bentley, Dr. Andrewes and Dr. Bourdillon—has been started at the Marble Arch Tube Station. Here the antiseptic mist is introduced into the plenum ventilating system, a method which is not applicable to all tube stations.

A further large-scale trial is being organized at the Bond Street Tube Station, where the sprays producing the mist will be operated by compressed air led in a pipe along the wall of the platform.

Even where the whole atmosphere cannot be treated it may be practicable to operate some form of " barrier " mist, and with Dr. Shinnie's help further trials are being carried out at a large shelter in Westminster.

It is important to have an apparatus which will produce a sufficiently fine mist. There are various types on the market, but much of the present hand spraying probably does not create a true bactericidal mist, though it has at least a psychological value. Perhaps the shade of Lister will note that something like his carbolic spray is coming into its own again.

Disinfection of the air alone is not enough, and methods should also be employed for treating the dust. Reports on the advantages of using spindle oil for this purpose have recently been published, but it has the disadvantage that floors may be slippery for some hours after treatment. The problem is being actively investigated at the National Institute for Medical Research by Dr. Van den Ende.

The principle of wearing masks for protection against droplet infection has been accepted as sound and capable of practical application.

There is another group of diseases against which precautions must be taken, namely, those that are spread by lice. The risk of the spread of body-vermin in the conditions found in some crowded shelters is fully appreciated, and the Ministry have the advantage of Prof. Buxton's help in the measures they are taking. Short courses of instruction have been arranged at the London School of Hygiene for shelter wardens, and a pamphlet has been issued giving briefly the essential facts in the life-history of the louse, the flea, and the bed-bug, and summarizing simple measures for dealing with these pests.

Whilst a few individuals are known to be lousy, there is no evidence at present that any special spread of these insects has occurred. Now is the time, however, to ensure that cleansing stations are capable of working to full capacity, and steps are being taken by the Ministry of Health to make mobile bathing and de-lousing stations available, but it is also desirable that medical officers of health should consider what improvised methods could be brought into use locally.

Issues are also being made of the new insecticidal powder A1.63, which possesses the property of hanging about garments and continuing effective up to about a week after it has been applied. Other new methods of control may also be brought into use later.

Mention must also be made of the mosquitoes in some of the tube railways, which the late Prof. Shipley would probably have included in his minor horrors of war. I was surprised when, towards the end of October, a woman told me in one of the tube stations that she was being badly bitten by mosquitoes. We at once arranged for the complaint to be investigated, and Mr. Shute, our assistant malaria officer, found that there were large collections of stagnant water in some of the old tubes, extending even under the inverts of the platforms, in which mosquitoes were actively breeding. In one unbroken stretch of water about 80 yards long there were enormous numbers of larvæ and pupæ, and the walls and ceilings of this particular stretch of tube were swarming with both male and female adults, a number containing undigested blood.

The only species of mosquito found has been *Culex molestus* which, although not a disease carrier, bites man viciously. Under natural conditions this mosquito hibernates from October to April, but in the underground tubes, where practically summer temperatures prevail and they can now obtain plentiful blood meals from the people sheltering, the adult mosquitoes have not gone into hibernation. Active measures have been taken, however, to deal with the nuisance. The collections of water are treated with cresol, which has the advantage of turning the water a milky white. It is easy, then, to detect untreated pools, and the milky colour of the water shows up the larvæ whether alive or dead. Spraying the walls and ceilings with some suitable preparation of pyrethrum will deal with the adults, but spraying is only a temporary expedient and the collections of water must either be pumped out or efficiently treated to prevent fresh adults emerging.

The problems of environmental hygiene are so well known that I need only touch on one of the major difficulties which have been encountered—insufficient latrine accommodation, often associated with bad siting, poor screening and even no light at all. Moreover, as the majority of latrines are of the pail type, inadequate emptying and cleansing have added to the nuisance which resulted. Naturally, in the deep shelters the difficulties of the cleansing service have been many. In some of the tube stations, however, great improvements have been effected by the installation of a hoppered cylinder into which the contents of the pails are emptied. By closing the valve between the hopper and the cylinder and turning on compressed air the contents of the cylinder are driven up a pipe which discharges into the sewer above.

Finally, a word on the value of good shelter management. The introduction of the ticket system has abolished queues, overcrowding is being reduced by the installation of bunks and better lighting is improving cleanliness. Great responsibility rests on the shelter wardens, who by their example and leadership can, and do, add so much to the well-being of those in their care.

The President said that each of the many types of *ad hoc* and adapted shelter—and they were legion—presented its own problem. In each the ventilation, forced or natural, and the necessity or otherwise of heating, adequate lighting, strict cleanliness, and emergency sanitation were interlocked problems for the engineer and the doctor. Outside the shelter itself lay an important part of the problem on the engineering and administrative side in the provision of ample facilities for bathing and disinfestation of clothes and bedding. The education of the sheltered population in personal hygiene, the immediate segregation of the infectious, and the provision of separate accommodation for the tuberculous were necessary. Immunization of children against diphtheria was even more necessary in their shelter life than in the ordinary life of school, home, or billet.

The difficulties were evident, but they would only stimulate the true epidemiologist. One defect alone seemed inherent and incurable—into no shelter could the beneficent

power of sunlight ever enter. In most shelters, added to darkness, two other cardinal sins of environment had to be confronted, namely, overcrowding and damp. Overcrowding facilitated the transmission of every infectious and contagious disease, and it was inevitable, as the Royal Commission said in 1861, that, "If above a certain number are placed in a given cubic space the lives of some and the health of others are certain to be sacrificed". The abatement of overcrowding was the most urgent problem, and in the broadest sense was mainly one of administration. Public Enemy No. 2 was damp, which was of three kinds: percolation from sides, roof, and floor, condensation, and, most important, the respiratory miasma which overhung all crowded assemblies of men or animals.

One point was that the use of school shelters by the public in any place where alerts or raids were at all frequent required special supervision. The time for cleansing might be inadequate, and considerable difficulty might be experienced in maintaining them in a fit state for the children's use.

The "blitz" started early in September, four months before the beginning of the epidemic season. This gave time not only for material improvement, but also for acclimatization to shelter conditions by the public, and the mutual interchange of nasopharyngeal organisms, with, it was to be hoped, some degree of non-specific immunization in the shelter population.

All things considered, up to now the infectious diseases had behaved well. In the last week for which he had the figures the notifications of diphtheria and scarlet fever, though numbering more than in the corresponding week of 1939, when they were remarkably low, were less numerous than for 1938. Pneumonia notifications were at about ordinary level. When it was considered how closely correlated all these diseases usually were with overcrowding and deficient ventilation, they had indeed been fortunate. Casualties so far had been extraordinarily small in proportion to the weight of the air attack, and for this they had mainly to thank the matchless R.A.F. and Defence Forces, but the shelters themselves had undoubtedly stood splinter and blast much better than many anticipated.

Dr. C. F. White (M.O.H., City of London) said that his experience was limited to public shelters in the City, and the problem in the City was peculiar. In peace-time the day population was about half a million, the night population under 10,000, largely caretakers for whom shelter was available in the premises in which they lived. The problem at first appeared to consist of providing temporary shelter for persons caught in the streets during daylight raiding, and, with considerable difficulty and at great expense, basements were acquired and surface shelters constructed. Even if prolonged night-raiding had been foreseen the City would not have been greatly perturbed about sheltering its own relatively small night population, but it had been invaded by some 20,000 people from neighbouring boroughs, and was continually being pressed to find accommodation for more. The majority of the visitors congregated in the four deep tube stations, but there were also available a long section of the newly-constructed extension of the Central London Railway, and three other shelters already occupied by over 500 persons every night. Several more were capable of accommodating that number, but were not filled to capacity because strutted basements were not popular with shelterers. Of the "under 500" class there were well over 100 shelters. There were no Anderson shelters.

Before the war every effort was being made to get rid of underground living, sleeping, and working places. Now rooms below ground were the most sought after, and the deeper they were, the more they were esteemed. The public had taken the matter into their own hands, with the result that the shelters which were popularly considered safe were grossly overcrowded. It was all very well to talk about dispersal, but it was extremely difficult to persuade people to leave an overcrowded, deep tube station or tunnel for a more comfortable, warmer, and more airy basement. Surface shelters were, in his experience, practically unused at night. Shelterers had a strong preference for a place where no high explosive bomb could reach them, and as a minimum they demanded to be where they could not hear aeroplanes overhead nor the sound of gunfire, and to secure this, they were prepared to endure great discomfort and run the risk of epidemic disease.

The principal sufferers, alike from deterioration of general health and acute infectious diseases, were likely to be the children. It was obviously desirable that all children should

be evacuated from London, but many still remained and others had returned. Compulsory evacuation, in his view, was not practicable. But if a child's health was definitely suffering as a result of shelter life or was endangered by the prevalence of epidemic disease in a shelter, it might be possible to insist that the child be evacuated or at least transferred to another shelter which, although not capable of standing up to a direct hit from a high explosive bomb, was, perhaps for that very reason, more hygienic. If the shelter doctor could certify that the health of a child was suffering or endangered, then he thought its removal could be enforced, with public sympathy on the side of the authorities. It might be necessary to have compulsory medical inspection at short intervals, say once a fortnight, of all children in public shelters.

It seemed improbable that the isolation hospitals would be able to take all the cases, including the minor infections, such as German measles or mumps. If the isolation hospitals could not take them they must be kept in the medical aid posts or adjoining sick bays or transferred to shelters reserved for minor cases of illness. He was strongly in favour of the latter course. A tube station platform was a most unsuitable place for any case of illness. Apart from infectious sickness, there was the necessity for the provision of beds in special shelters for any type of case which would normally recover after a day or two in bed at home, with or without medical attention.

In the disinfection of the air of public shelters he found it difficult to believe that aerosols would be of much value in the enormous spaces with which it was necessary to deal. The barrier method might be practicable and useful if the infectious cases could be concentrated in a certain part of the shelter. If special shelters were established for the sick, aerosols might prove of great value in preventing spread of infection.

Adequate ventilation of deep shelters presented another problem. It was useless at the present time to expect the installation of efficient mechanical ventilation, because neither the material nor the labour was available. The best must be done to obtain through-ventilation by keeping open both entrances and emergency exits, and to relieve the physical effects of air stagnation by the use of electric fans.

Heating of shelters might or might not be necessary. Deep, overcrowded shelters were usually too hot and too humid. In one tunnel the temperature was never less than 70° at night, and might soar towards the eighties. The smaller shelters with concrete floors and brick walls were usually too cold, particularly if sparsely occupied; yet on account of deficient ventilation no means of heating which would contribute to the vitiation of the atmosphere could be introduced. Electrical heating was expensive and the necessary fittings not easily obtainable. The shelterers must make the adjustment by wearing more clothing or having more bedding.

The main trouble with lighting was that while in the first part of the evening the shelterers should have sufficient light to enable them to read a newspaper, later on the light should be reduced to such intensity as would not interfere with sleep but would yet enable them to find their way about should any emergency arise.

Dampness might arise from leakages or from condensation. The former must be dealt with according to circumstances, though in many cases it was impossible to provide a remedy. The latter could be controlled only by adequate ventilation and heating or by insulating the cold surfaces.

The disposal of excreta from public shelters was an enormous task. In the majority of shelters some form of conservancy system was inevitable. In the City, in the expectation that the shelterers would be mainly persons employed in offices or shops, an excellent type of chemical closet was installed in the proportion of one closet to every 25 persons of the day capacity. As the night capacity was from one-half to one-third of the day capacity there was an ample supply of conveniences, but their present condition was an indication of the type of person using the shelter at night. He had been appalled at the way in which these closets were abused by a certain section of the population. Lids and seats were destroyed, tops, outsides, and surrounding ground fouled, and the whole compartment an offence. In future he recommended a strong pail straddled by a simple wooden frame which would afford support during defæcation, but could be removed entirely by those who were afraid to have contact with the seat of a public closet. In the

pail he would have only a solution of some coal-tar disinfectant as a deodorant. He would not consider anti-splash devices or the use of a heavy oil seal or any solvent.

In the tube stations it was almost impossible to find room for an adequate number of closets. The L.P.T.B. were trying to work to a figure of one convenience to every 75 shelterers, but he doubted whether they would attain even this. In the City the large public conveniences in close proximity to the tube stations were kept open free to both men and women all night long, but the results had been disappointing. The shelterers either would not take the trouble or were afraid to make the short journey half-way across the street. The only thing to do in the tube stations was to arrange for the closets to be kept under observation and emptied as necessary during the night. The installation of the pneumatic ejector systems would greatly reduce labour.

Unless the shelterers kept themselves and their clothing and bedding clean there was sure to be serious infestation with lice. No serious infestation had as yet occurred in the City, but he was afraid this would not continue. Ascertainment of extent of louse infestation was difficult, and they would have to depend on the complaints of other shelterers combined with reports of shelter doctors, who should take every opportunity unobtrusively to look for evidence of lousiness in patients who came to the medical aid posts. If louse-borne disease broke out, of course, more direct methods of ascertainment would have to be adopted.

The majority of shelterers still had their own homes intact, and might reasonably be expected to return there in the daytime to keep themselves and their clothing and bedding clean, but some were homeless, and others went from the shelter straight to work in the morning and returned direct in the evening. For these some opportunity of personal ablution at least must be provided. In the City there were no public baths or wash-houses ; all that could be done was to give the free use of lavatory basins in the public conveniences near the large shelters, but unless an attendant were kept on duty all night, hot water could not be provided. For the washing of clothing and bedding shelterers must be referred to their own districts. Bedding might be the principal source of trouble. It might be disinfected by steam, but unless at the same time the personal clothing was disinfected and the people bathed themselves, this measure would be of little value in checking louse infestation. This would mean that people who required delousing must carry their own bedding to the cleansing and disinfecting stations. It would be useless to take van loads of bedding to the disinfectors from the shelters because, apart from dealing with only half the problem, there would be endless claims that the bedding returned was not the bedding which had been removed or that it had been damaged by disinfection. No doubt there would have to be further powers to compel persons who were infested with vermin to any degree to attend with their bedding for cleansing. Pressure might also be brought to bear by withdrawing shelter tickets. Bunks would have to be dealt with in situ by the application of liquid insecticides. If the bunks were dismantled and the liquid carefully and conscientiously applied, this method should be effective. Any form of fumigation of public shelters appeared to be impracticable. He had no experience of the application of louse-killing powders to the clothing of civilians, but this method would have great advantages over steam disinfection. The infested people could rub it into their clothes themselves ; it would not damage the clothing ; there would be no risk of dampness as there always was with steam disinfection, and the deterrent effect on lice would persist for some days at least.

Never was there a time when it was more necessary and more practicable to instruct the public in personal hygiene. There was a wide scope and a great opportunity for health education, which must be clear and precise. Doctors were too much inclined to include in their statements the qualifying phrases which scientific accuracy demanded, and in propaganda these were fatal: those who were inclined to follow the advice did so half-heartedly, and those who were looking for an excuse to do nothing seized on the words which provided it.

Finally, he asked the critics of the medical officer of health to realize the conditions under which he was working : masses of people living in places never intended for human habitation and in conditions which in peace-time would never be tolerated. It was often difficult to make the improvements which were practicable because the first call on

materials and labour was for the prosecution of the war. The result was that work which contractors would normally compete for did not now interest them ; they already had in hand as much as they could cope with, and so small jobs which might be completed in a few days could not be even begun for weeks.

It was all a series of compromises and expedients, and he feared that, in spite of all their efforts, really hygienic conditions in public shelters would never be achieved.

Dr. S. Davidson said that as a general practitioner he had had some experience in the Belsize Park and Hampstead tube shelters and had also visited a number of other shelters. In his view they were optimistic in thinking that they were going to escape a major epidemic unless much more care was taken than was being taken to-day. He found himself not quite in agreement with Dr. Stock, who said that the people of London went to the tubes and to the safer shelters as the result of the herd instinct or from fancy. In the tube stations at Hampstead and Belsize Park—the deepest in London—and also at the Tilbury shelter in the East End, the majority of the people now were those who had been bombed out of their houses or lived in such bad conditions, with so little shelter in their houses, that they were forced to go down into the public shelter. The people who inhabited Belsize Park and Hampstead Tube Stations came from all over London, and here they thought, naturally, they were much more safe. He would have challenged anyone to come with him three or four weeks ago to the brick surface shelters in the Hampstead quarter ; they would have found them almost unoccupied, and that for a specific reason, that the people could get much better protection from a deep shelter, and were willing to risk even the danger of contracting a disease in the interests of their own safety. That feeling must not be under-estimated. Nothing had been said that afternoon about the possibilities of protection against the physical effects of bombardment. There must be a very adequate reason why people sought the overcrowded Tilbury shelter or the railway arches or the tubes, and the reason was that the people felt themselves much safer than in the average brick shelter or the strutted basement. If overcrowding was to be avoided they must be provided with a shelter which to them appeared to be safe. It was not sufficient to ask people to disperse. Moreover, it must be borne in mind that eight or ten people in an Anderson shelter or 50 or 60 people in a brick shelter were just as overcrowded as 2,000 or 3,000 people on a tube platform. He thought that the medical profession as a whole ought to concern itself with the possibility of providing some form of bomb-proof shelter, possibly on the Haldane model, as outlined by the A.R.P. Co-ordinating Committee, which would not only afford safety, but would give scope for the practice of dispersal. To suppose that people would leave the adequate safety of the tubes for an Anderson or a brick shelter was a delusion. One had to see the conditions obtaining in the Tilbury shelter to believe that people could live under such circumstances. They did not do it from any herd instinct or personal fancy, they did it because they really believed that they were going to be safe there.

It had not been adequately stressed that the local authorities as such should have full legal responsibility for dealing with the tubes. The medical officer of health should have full responsibility for them. In some of them—up to four days ago at least—buckets were being used with very inadequate provision against de-sanitation, spilling all over the platform, in his opinion involving a very serious menace of typhoid infection.

It was not sufficient to say that the people ought to keep themselves warm by the provision of blankets. It must be ensured that the blankets were adequately sterilized, and the people themselves could not be expected to do that. Some building ought to be given over to the local medical authorities to deal with sterilization of the bedding.

Dr. Sinclair-Loutit, speaking with regard to the condition of the latrines, said that most of the fouling was caused by young children who found the adult-size chemical closet too big a problem to tackle. The very generous provision of one closet to 25 shelterers, if a fair proportion of small closets were included, would make a great difference. Proper lighting would also assist. He himself had discovered that the chemical closet was a false economy, since though the initial cost of the water closet appeared high, renewal and constant emptying of the chemical containers involved far greater ultimate cost.

Another problem concerned the people who were ill but not in hospital. In a population of some 50,000 there were roughly 1,400 cases of notifiable disease, of which only some 600 went to hospital, the remainder being nursed in their own homes. The population of the area he had in mind was now reduced to 38,000, but this still left a large number of people with notifiable disease who remained in their own homes and, for that matter, used ordinary shelters. Amongst these people, again, there were a number of young adults—about 350—with a history of tuberculosis, and some plan must immediately be found for dealing not only with the young tubercular person who had been discharged from a sanatorium, but also for those hundreds of people who were in an infectious state, and who had as much right to the use of an air-raid shelter as the sound members of the community. There must be some rearrangement of shelter space and allocation of special space for these conditions, whereby a great deal could be done to help this section of the population. He had heard that there were plans in several London boroughs for providing special space, particularly for tubercular people, but this large unhospitalized fraction must also be remembered.

Dr. E. Ashworth Underwood spoke first of all in connexion with the isolation of tuberculous persons. He had had this under discussion at various meetings. It was analogous to the question of providing special houses for the tuberculous, and personally he did not believe that the provision of such isolation accommodation in shelters would meet with any success. The psychological factor of asking people to declare themselves tuberculous by going into special accommodation would immediately create difficulties. Related to this was the provision of isolation accommodation for chest diseases, influenza, and the minor fevers. The Ministry, in their circulars, had referred to this matter, but he was not aware that any circular had so far set out specifically the proportion of accommodation which should be reserved for this purpose. In the case of his largest shelter—a deep tube, where there were at one time 4,000 persons—he had recommended that a certain proportion of space should be set aside for this purpose, but if such accommodation was used normally when there were no epidemics there would be the very greatest difficulty in shifting the previous tenants out of their bunks and transferring them elsewhere when this reserved space was required for isolating cases. This difficulty would be made greater by the ticket system for the allotment of bunks.

In the diagram of the medical aid post shown by Dr. Stock, he thought that the bunks provided for in the isolation section, if the shelter was a large one, were too few. In the case of a large shelter accommodating several thousand persons, if the sick bay accommodation was put all in one place it looked rather a large amount, and when the persons in the shelter saw the large number of beds and bunks so reserved, they were inclined to criticize and to say that the space was being wasted.

The provision of lavatory accommodation was difficult, especially in large shelters. Several complaints had been made that the lavatories in the shelters which were sectioned were too close to the bunks, and people did not like to use such lavatories. In a very large shelter, as in a tube, if the lavatories were divided up into small sections and spaced off in the shelter, it was possible that this psychological attitude on the part of the shelterers might lead to some persons going outside altogether and fouling the surrounding ground.

In the large shelters washing facilities should be provided ; the provision of water and the disposal of waste would create a minor engineering problem.

As for infestation, he had looked very carefully and had so far found no evidence of it in the shelters for which he was responsible. There might have been odd cases in which underclothing was infested. While he hoped that the present apparent immunity would continue, it seemed almost too much to expect in view of the conditions existing. On the question of disinfection of blankets, Dr. Davidson had said that the local authority ought to be responsible for cleansing and disinfestation. But such a problem could not be tackled in a matter of a week or so. Many authorities had not got the facilities for large-scale disinfection of this nature, and some form of travelling disinfector would have to be introduced, and here the question of supply would come in.

The suggestion had been made that it might be possible to introduce some form of ultra-violet ray apparatus into the larger shelters, to counteract the effects of lack of

sunlight in the case of certain persons who were not inclined to leave the shelter even during the day.

Both the Ministry of Health and the Ministry of Home Security had given all the help possible in this very difficult problem. He thought that the co-operation between the two Ministries should be facilitated and increased, in order to avoid delay.

Dr. A. Benjamin pleaded for more co-ordination between the engineering and the medical departments of the local authority, and also for more authority to the medical department. He related a case in which a surface shelter was scheduled to give protection to 180 people sitting. In due course bunks were installed in the shelters in his neighbourhood, without apparently any of the medical authorities knowing anything about them. Bunks for 180 people were put in this shelter. When he discovered it, realizing the overcrowding, he endeavoured at once to get some of the bunks removed. According to his estimate the safe number was 132. That was over a fortnight ago, and up to now not quite half the surplus bunks had been removed. This shelter was divided into two parts ; one part had exactly the proper number of bunks, that is to say, 66, but the other part was overcrowded. But the method of distribution of the bunks, even when not more than the required number were installed, was bad. They were too close together. He had wanted to redistribute the bunks, but even when the medical officer of health visited the shelter with him a few nights previously he was not in a position to order the redistribution. He had to ask the shelter marshal if he would make representations to the proper quarter, and the people all this time were running the risk of unnecessary proximity with regard to infection. In addition the overcrowding meant that, if it was necessary to make a hurried exit, there was only one narrow passage available.

Dr. W. H. Bradley said that there was no need for him to emphasize the importance of droplet infection in the shelters. They were all of them accustomed to the idea of wearing masks in operating theatres, labour rooms, children's wards, and many infectious diseases wards. The National Institute for Medical Research had been looking for a remedy which would undo the evil of those three cardinal sins to which the President had referred, namely, overcrowding, inadequate ventilation, and absence of sunlight in air-raid shelters. Dr. Andrewes and Dr. Bourdillon had pointed out in a paper in the *Lancet* how droplet infection might possibly be controlled by disinfection of the air with aerosols and by keeping down dust, and they had also worked out the possibility of introducing masks for use in the shelters. All doctors were used to the idea of masks, and did not mind the trifling discomfort, but the shelter population, on the other hand, might not take very kindly to them. The conditions in air-raid shelters were very different from those in an operating theatre. There were extremes of temperature and of humidity, and, therefore, the problems associated with masks, if they were to be applied in air-raid shelters, were particularly difficult ones. There was one other great difficulty : the mask after use was a very filthy thing, and must be cleaned or sterilized.

From all this, many people might at once conclude that the application of masks in shelters was quite impracticable, but perhaps it was going to be worth while to have a "shot" at it, and so he wanted to show some lantern-slides which Dr. Bourdillon had lent him illustrating the type of mask which seemed best to meet the need. (In the laboratory a true sneeze or cough was difficult to reproduce and a "pressure spit" was used for test purposes.) His first slide showed a sheet of cellulose acetate held 2 ft. 6 in. away from a man who had spat, and it revealed many hundreds of thousands of colonies. If a screen of cellulose acetate were slung in front of the mouth at the time of this "pressure spit" the whole of that enormous spray of moisture was diverted downwards. Successive slides showed what the mask could do in the way of diversion ; also the effect of four layers of muslin, which, however, was penetrated by some of the spit. In their studies at Hampstead, Drs. Andrewes and Bourdillon had found that there was not any easily worn form of mask which would completely stop the inhalation of organisms sprayed into the air, and they had come to the conclusion that the one thing that could be done with reasonable effectiveness was to prevent direct projectile infection. Unfortunately, the type of mask so far devised for this purpose might not be acceptable in shelters, and yet it seemed reasonable to try to arrive at a design which could be worn. He had made some field observations on the subject with a view to discovering what were

the main difficulties about wearing masks in the shelters. These seemed to be self-consciousness, shyness, absence of æsthetic appeal in the mask, but in addition there was the general indifference of the shelter population in the absence of any threat of infection. Still another difficulty was the question of condensation. Masks very soon became moist and uncomfortable. A practical difficulty was the sterilization of the gauze type of mask which could not be cleaned as easily as the cellulose acetate screen by simply sponging and polishing. An endeavour had been made to devise a mask which might be acceptable, and he showed the result so far as it had gone—a quite engaging form of drapery over the lower part of the face of a young woman.

It would be helpful to have opinions about the use of masks, because if they could be introduced they would do a great deal in the way of preventing direct projectile infection. But in their application they gave rise to many difficulties, for the removal of which help would be esteemed.

Lord Horder congratulated the officers of the Section on staging the discussion, which must be helpful to them all. He complimented Dr. Stock also on the lucid way in which he had presented this difficult subject. He wished also to thank Dr. Stock for the great help which he had given to him and to his Committee. The speaker himself might have been betrayed into many unwise enthusiasms if he had not frequently been checked by Dr. Stock telling him what could, and could not, be done.

In this discussion he wished to confine himself to a few general considerations. He had always regarded the shelter problem as an emergency problem, rather like an acute, if not fulminating, disease—calling for medical measures, so far, rather than surgical. He felt that they would never arrive at an ideal shelter—how could they? It was in the large public shelter that the hygienic problem was to be found, and it had to be dealt with in opportunist fashion. The difficulties had to be diminished as much as possible—they would never be entirely removed. Again and again the views of experts had to be taken, and at the end of discussions by these, when they were pressed for a conclusion, this was apt to assume almost a negative form—that nothing could be done about it. As an illustration they were told that in the matter of air space per individual the nearest thing to a shelter was a canal barge, but, then, a shelter was not a canal barge, "and therefore we cannot help you". In his view recommendations should be couched in positive, not negative, terms if they were to be of any use. Again, a recommendation which was not practicable was no good. Finally, the psychological factor must always be borne in mind, and one must not be afraid of making suggestions which sounded to the scientific ear a little trivial.

Granted that the whole thing was a hideous emergency thrust upon them, there were two policies, and he thought it not incompatible that those two policies should go on side by side, although some people thought them mutually exclusive. There was a long-term policy, and the reference in regard to that was to unload. But it took a long time to unload these shelters. Then there was a short-term policy, of which cognizance must be taken if the situation was to be saved before the height of incidence of epidemic disease was upon them. They had to deal with a hard core of people who insisted on underground shelters; whether it was the herd instinct, or an ostrich-like propensity, they thought themselves safe underground. Dr. Davidson had raised the question of safety, and had said that he thought doctors ought to concern themselves with that question. Lord Horder could not agree with that. The question of the safety of the shelters rested foursquare upon the Ministry of Home Security. But however that might be, the question of safety as between underground and overground shelters so far as fatal casualties were concerned up to the present was about equally balanced. The people who sought deep shelters did not realize that some of these were under military objectives: the people who sought refuge in them would really be safer in their own houses.

He desired to add something about the compensations of the present situation. This emergency problem presented a unique field for research; that field was being entered by a number of men who were doing good work and this must not only contribute to the solution of the problem before they were through with it, but also contribute in a valuable way to preventive medicine in general. Again, as one speaker had reminded them, it had

opened up a field also for health education second to none in the speaker's own recollection of hygiene and the teaching of hygiene principles. These people were "as good as gold" in the way of listening, and as good as they could be, which was saying a great deal, in carrying out the various hints that were afforded them by the medical officers of health and their assistants and by the doctors who came in from outside. In all this there was a field for research and for health education second to none, and he thought those two things ought to be remembered and the utmost use made of them.

He wished to add only this, that he trembled every time he signed the final wording of a recommendation as to the reaction which it would provoke amongst his colleagues, and he was amazed either at his luck, or at the extreme kindliness of his colleagues, because up till now his attention had not been drawn to any very obvious blunder.

Dr. Stock, in reply to the discussion, said that as the black-out was upon them he would curtail his remarks. He expressed the hope that local authorities would note the point made by the President in regard to school shelters which were used by the public during the night and arrange for the necessary cleansing in the morning.

He generally agreed with everything Dr. White had said but thought he was a little pessimistic in regard to the use of aerosols. The idea behind the mobile disinfecting units was to provide facilities for treating bedding, &c., when the local resources were inadequate. There were difficulties about supply but if the Ministry of Health got the number they had asked for he promised that a mobile unit should be allocated to the City of London.

When speaking of the "herd" instinct, the statement was a general one and he was not particularly referring to the shelters in Hampstead. All the same, the general opinion was that the "herd" instinct had played, and continued to play, a great part in the shelter problem. Many people like to congregate together in the big shelters and the Tilbury shelter to which he had referred was a bequeathment from the last war when, for some reason or other, people thought the Tilbury Arches were a safe shelter. He understood Dr. Davidson to suggest that the Medical Officer of Health should be made responsible for the cleansing services, which might or might not be a good thing. When he himself was Medical Officer of Health in Johannesburg the cleansing department was a branch of the health department, but in this country the cleansing department usually came under the borough surveyor. The Medical Officer of Health had to rely on his colleagues to get matters put right. These were not normal times and the borough surveyor carried a heavy load but, nevertheless, he doubted whether this was the time to transfer the responsibility for the cleansing services to the Medical Officer of Health.

He agreed with much that Dr. Sinclair-Loutit and Dr. Davidson had said. He pointed out that even in the limited discussion that afternoon there was no agreement on the best provision to be made for tubercular people. As regards the size of the medical aid post the sketch plan shown was a unit for 500 persons and would have to be enlarged or other units must be provided for shelters accommodating thousands of people. He agreed with Dr. Underwood that the accommodation shown in the isolation section might not be sufficient and that additional accommodation might have to be extemporised. Dr. Underwood had quite rightly stressed the problem of lousiness and additional powers for dealing with verminous persons would soon be available. It was a condition for which they must be constantly on the watch but up to the present, although skilled investigators had been at work, no evidence had been obtained of any marked increase of lousiness.

In regard to the bunking of shelters it was laid down in the official circular that the minimum space between rows of bunks must be 2 feet, and if conditions rendered this impossible then wooden partitions must be provided between the heads. The idea was to lessen the risk of droplet infection and to provide much greater protection than the arrangement Dr. Benjamin had described.

Lord Horder had asked him to mention one point in regard to masks. The further recommendations of the Horder Committee were appearing in a White Paper and when the White Paper appeared he thought that the recommendations in regard to masks would be found to follow the advice given by Dr. Andrewes and his colleagues of the National Institute for Medical Research. He entirely agreed with what Lord Horder had said about not having half-hearted recommendations, and one characteristic of the conditions

which the Horder Committee had formulated and which had been accepted by the Government was their definite character.

What the future held he did not know. It was easy to speculate but if they took all possible precautions there was no reason why they should not hope that some of them might be unnecessary. One factor which gave grounds for hope that the shelter population of London might be saved from the disasters of major epidemics was the constitution of the "herd" in the public shelters. After all, the "herd" have much the same constitution as the ordinary population of London, but a large number of the more susceptible members, namely, the children, had been removed.

Section of Proctology

President—W. B. GABRIEL, M.S.

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Squamous-cell Carcinoma of the Anus and Anal Canal: An Analysis of 55 Cases

PRESIDENT'S ADDRESS

By W. B. GABRIEL, M.S., F.R.C.S.

ABSTRACT.—The analysis is of 55 cases admitted into St. Mark's Hospital from 1922 to 1940.

The incidence was 3·35% of all cases of cancer of the rectum, anal canal and anus admitted during this period.

Sex distribution—27 males and 28 females.

The average age (61·7 years) is higher than that of columnar-cell carcinoma of the rectum (57·4 years).

Histology.—The cases have been graded into three grades of malignancy—low grade, medium grade, and high grade.

Low grade squamous carcinoma is twice as frequent in men as in women, and generally originates at the anal margin.

Medium grade squamous carcinoma is equally distributed between men and women; it may arise at the anus or in the anal canal.

High grade squamous carcinoma is much more common in the female sex and is almost entirely limited to the anal canal.

Quadrant affected—about one-third of the anal margin growths and one-half of the anal canal growths were situated anteriorly.

Differential diagnosis from simple papilloma, simple ulcer, chronic inflammation, tuberculous ulcer, tuberculide, primary chancre, amœbic ulcer, basal-cell carcinoma, columnar-cell carcinoma.

Biopsy and grading essential before treatment is decided upon.

The results of treatment in the three grades of malignancy are described. The best results were obtained in the early low-grade cases treated by interstitial radium needling. In the medium and high grades only three five-year survivals can be reported and these followed excision of the rectum. The management of the inguinal glands is discussed and the importance of a very close post-operative supervision emphasized.

Squamous carcinoma of the anal canal may cause lymphatic metastases in the superior hæmorrhoidal glands; there have been four such cases in this series. Diathermy perineal excision is indicated in these cases.

RÉSUMÉ.—Analyse de 55 cas de cancer à cellules squameuses de l'anus et du canal anal observés à l'Hôpital St. Mark de 1922 à 1940.

Ces cas représentent 3·35 pour cent des cas de cancer du rectum, du canal anal et de l'anus observés pendant cette période.

Distribution des cas entre les sexes : 27 hommes et 28 femmes.

L'âge moyen (61·7 ans) est plus élevé que pour le cancer à cellules cylindriques du rectum (57·4 ans).

Histologie.—Les cas ont été classifiés en trois degrés de malignité : faible, moyenne et haute.

Le cancer de malignité faible est deux fois plus fréquent chez l'homme que chez la femme, et commence généralement à la marge de l'anus.

Le cancer de malignité moyenne est distribué également entre les sexes, et peut commencer à l'anus ou dans le canal anal.

Le cancer de malignité haute est beaucoup plus fréquent chez la femme, et se trouve presque exclusivement dans le canal anal.

Quadrant affecté—environ un tiers des tumeurs de la marge de l'anus et la moitié des tumeurs du canal anal sont situées antérieurement.

Diagnostic différentiel entre ces tumeurs et les papillomes simples, les ulcères simples, les inflammations chroniques, les ulcères tuberculeux, les tuberculides, les chancres primaires, les ulcères amibiques, le cancer à cellules basales, et les cancers à cellules cylindriques.

Avant de choisir le traitement il est nécessaire de faire une biopsie et de déterminer le degré de malignité de la tumeur.

Les résultats du traitement des tumeurs des différents degrés de malignité sont rapportés. Les meilleurs résultats ont été obtenus par le traitement *précoce* du cancer de malignité faible par l'introduction d'aiguilles à radium. Parmi les cas de malignité moyenne ou prononcée seulement trois guérisons datant de plus de cinq ans ont été obtenues, toujours par l'excision du rectum. L'auteur discute le traitement des glandes inguinales et appuie fortement l'importance d'une surveillance post-opératoire soigneuse.

Le cancer à cellules squameuses du canal anal peut causer des métastases lymphatiques dans les glandes hémorroïdales supérieures; quatre cas en ont été observés dans cette série. L'excision par la diathermie périnéale est indiquée dans ces cas.

RESUMEN.—Se analizan 55 casos ingresando al Hospital de San Marco desde 1922 hasta 1940.

La incidencia era el 3,35% de todos los casos de cáncer del recto, canal ano-rectal y ano admitidos durante este período.

Distribución respecto a sexos—27 hombres y 28 mujeres.

El edad media (61,7 años) es más alta que la del carcinoma de células cilíndricas del recto (57,4 años).

Histologia.—Ordenáronse los casos en tres grados de malignidad: bajo, medio y alto.

La frecuencia del carcinoma escamoso de grado bajo es el doble en los hombres que en las mujeres; nace en general al borde del ano.

El carcinoma escamoso de grado medio se distribuye igualmente entre los hombres y las mujeres; puede iniciar al ano o en el canal ano-rectal.

El carcinoma escamoso de grado alto es mucho más frecuente en el sexo femenino y se limita casi enteramente al canal ano-rectal.

Cuadrante afectado—como la tercera parte de los tumores del borde anal y la mitad de los del canal ano-rectal se situaban anteriormente.

Diagnóstico diferencial con el papiloma simple, la úlcera simple, la inflamación crónica, la úlcera tuberculosa, la tuberculide, el chancro primario, la úlcera amíbica, el carcinoma baso-celular, el carcinoma a células cilíndricas.

La biopsia y la clasificación en grados son indispensables antes de decidir el tratamiento.

Descríbense las resultas de tratamiento en los tres grados de malignidad. Se obtuvieron las mejores resultas en los tipos de baja malignidad tratados muy temprano por curieterapia intersticial. En los grados medios y altos sólo pueden señalarse tres sobrevidas de 5 años, y éstas sigieron a la excisión del recto. Háblase del manejo de los ganglios inguinales, y se insiste sobre la importancia de una vigilancia postoperatoria muy cuidadosa.

El carcinoma escamoso del canal ano-rectal puede causar metastasis linfáticas en los ganglios hemorroidales superiores; había 4 casos en esta serie. La excisión perineal por diatermia está indicada en tal caso.

RESUMO.—A analise diz respeito a 55 casos tratados no Hospital de S. Marcos, de 1922 até 1940.

A incidencia foi de 3·3 por cento em todos os casos de cancro do recto, canal anal e do anus, tratados durante este periodo.

Distribuição por sexos: 27 homens e 28 mulheres.

A media da edade (61·7 anos) é mais elevada do que a do carcinoma de celula colunar do recto (57·4 anos).

Histologia.—Os casos foram divididos em trez categorias de malignidade: baixa, media e alta.

O carcinoma de baixa malignidade é duas veses mais frequente nos homens do que nas mulheres, e tem origem geralmente no rebordo anal.

O carcinoma escamoso de media malignidade aparece tanto nos homens como nas mulheres. Pode aparecer no anus, ou no canal anal.

O carcinoma escamoso de alta malignidade é muito mais frequente no sexo feminino e limita—se quasi sempre ao canal anal.

Quadrante afetado—cerca de um terço dos neoplasmas do rebordo anal e metade dos do canal anal estão situados anteriormente.

Diagnose diferencial de papiloma simples, ulcera simples, inflamação cronica, ulcera tuberculosa, tuberculide, cancro primario, ulcera amoebica, carcinoma das celulas basilares, carcinoma das celulas colunares.

A biopsia e a classificação são essenciaes antes de se começar o tratamento.

Os resultados do tratamento nas trez categorias de malignidade estão já descritos. Os melhores resultados foram obtidos nos casos de baixa malignidade recente, pelas agulhas de radio intersticiaes. Nas categorias media e alta, somente trez sobreviveram 5 anos e depois de se sujeitarem á excisão do recto. O tratamento das glandulas inguinaes é ponto de discussão, insistindo—se na importancia de se prestar atenção muito especial aos doentes depois da operação.

O carcinoma escamoso do canal anal pode causar metastases nas glandulas hemorroidaes superiores; tendo havido 4 destes casos nesta serie. A excisão perineal diatermica está indicada nestes casos.

CARCINOMA arising in the squamous epithelium of the anal canal and anal margin admittedly constitutes only a small proportion of all rectal cancers, but the subject is nevertheless one of importance from the point of view of incidence, diagnosis, the choice of treatment and prospects of cure.

In the hope that some facts of interest and usefulness will emerge I have undertaken an analysis of the cases of this disease admitted into St. Mark's Hospital during the last eighteen years.

INCIDENCE

The figures for cancer of the rectum published by Cuthbert Dukes [1] show that the cases of rectal cancer treated at St. Mark's Hospital are a fair sample of the disease as judged by the Registrar-General's statistics. With the invaluable assistance of our Follow-up Scheme at St. Mark's Hospital, which has now been in existence since 1922, financed by the Medical Research Council, it is possible to give a very accurate figure for the incidence of squamous-cell carcinoma of the anal canal and anus.

Since 1922, fifty-seven proved cases of squamous-cell carcinoma have been entered at St. Mark's Hospital and during this period of nearly nineteen years approximately 1,700 cases of cancer of the rectum, anal canal and anus have been admitted. The proportion of squamous carcinoma to the total is thus 3·35%.

The rest of this paper will deal with 55 cases in which the microscopical sections have proved available for further scrutiny and analysis: in two cases (1 male, 1 female) dating from 1922 the sections cannot now be found, so they have been excluded from further consideration, although the diagnosis of squamous carcinoma was unquestionably established at the time.

Sex.—Squamous-cell carcinoma of the anal canal and anus has an equal distribution between males and females. In this series there were 27 males and 28 females. The disease differs in this respect from adenocarcinoma of the rectum which is nearly twice as common in men as in women. It will, however, be shown in a subsequent paragraph that there appears to be an important difference in the sex distribution when the cases arising primarily in the anal canal are separated from those arising at the anal margin.

Age.—The average age at the date of admission was 61·7 years, which is distinctly higher than that of 57·4 which Dukes (*loc supra cit.*) has found to be the average age in a series of 1,000 cases of adenocarcinoma of the rectum (Table I).

TABLE I.—AGE AT ENTRY FOR SQUAMOUS CARCINOMA OF THE ANAL CANAL AND ANUS.

Age-group	Both sexes	Males	Females
20—39	1	0	1
40—59	22	12	10
60—79	32	15	17
Total	55	27	28
Average age	61·7	61·7	61·6

It will be seen that the average ages of the two sexes are almost identical. The other point which should be noted is that 32 out of the 55 cases fall into the age-group 60-79, whereas in the case of adenocarcinoma of the rectum the age-group 40-59 predominates (*see* Table V).

Histology

Squamous-cell carcinoma of the anus and anal canal may arise in the skin of the anal margin and the lowest part of the anal canal, or in the modified (transitional) epithelium which constitutes the lining of the anal canal from the level of the anal intermuscular sulcus or septum up to the pectinate line. Presumably a squamous-cell carcinoma may very well arise from the pectinate line itself and from the sinuses of Morgagni, exposed as these little pockets must be to constant fæcal trauma and the irritation of fæcal matter retained in them. Above the pectinate line the natural lining of cuboid and columnar epithelium may undergo squamous-cell metaplasia. This is commonly seen in connexion with prolapsing piles of the third degree, in chronic cases of mucosal prolapse and in certain cases of chronic hypertrophic proctitis, when islets of white squamous epithelium are recognizable on the mucous membrane; they may be considered to constitute a potential source for the origin of a squamous-cell carcinoma of the anal canal.

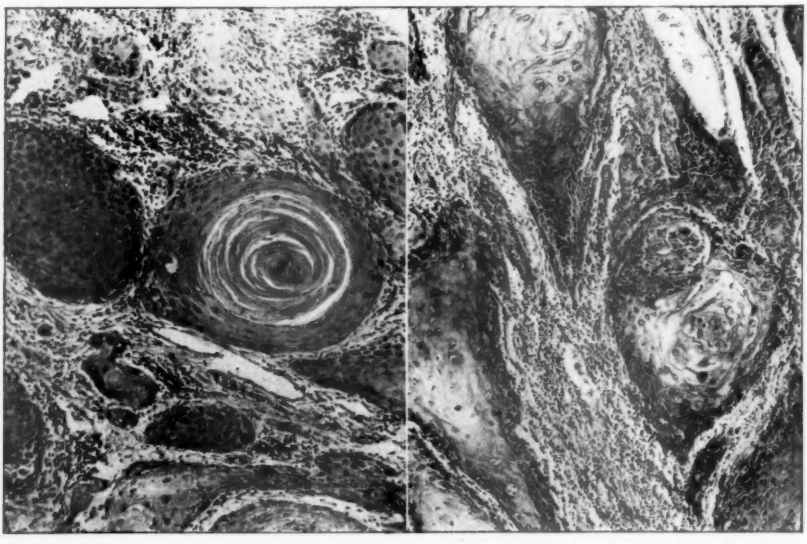

Fig. 1.—Squamous-cell carcinoma. Low-grade malignancy. × 90. Sections from two different cases.

In conjunction with my colleagues, Dr. Cuthbert Dukes and Mr. O. V. Lloyd-Davies, I have studied the histology of these 55 cases. Applying the well-known principle of cell-differentiation, Dr. Dukes advised that the cases should be divided into three grades of malignancy :—

(1) *Low grade.*—Well differentiated, with much keratinization and numerous well-marked cell-nests (fig. 1).

(2) *Medium grade.*—More cellular, with little differentiation and few cell nests (fig. 2).

(3) *High grade.*—Extremely cellular and undifferentiated, and usually with a total absence of keratinization (fig. 3).

There are, moreover, good precedents for recognizing these three grades of malignancy. Broders himself [2] when grading carcinoma of the cervix, found that only three grades could be made out, and Greenough's classification of carcinoma of the breast into three grades of low, medium and high malignancy is well known [3].

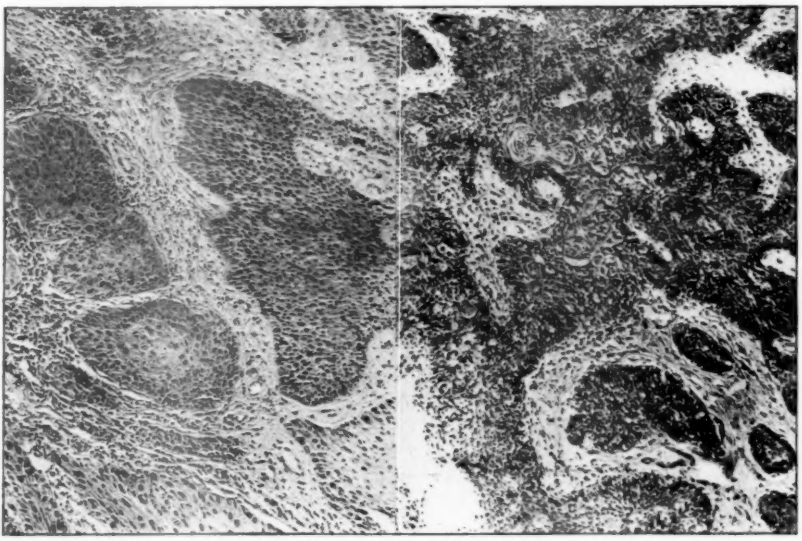

FIG. 2.—Squamous-cell carcinoma. Medium-grade malignancy. × 90. Sections from two different cases.

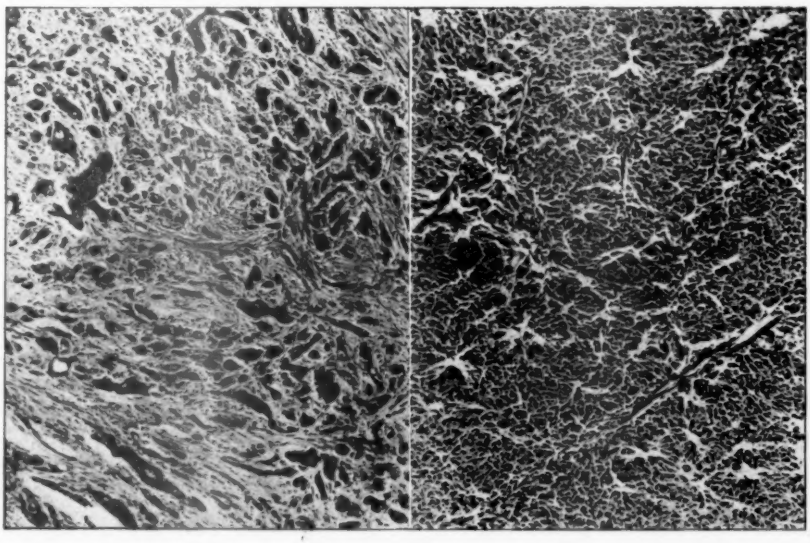

FIG. 3.—Squamous-cell carcinoma. High-grade malignancy. × 90. Sections from two different cases.

TABLE II.—DIVISION OF 55 CASES OF SQUAMOUS-CELL CARCINOMA OF THE ANUS AND ANAL CANAL INTO THREE GRADES OF MALIGNANCY.

	Males	Females	Total
Low grade	15	7	22
Medium grade	10	11	21
High grade	2	10	12
Total	27	28	55

Although this series is admittedly small an interesting difference between the sexes is to be noted, in that low-grade squamous carcinoma appears to be twice as common in men than women ; in the medium grade of malignancy the sexes are equal, whereas in the high grade of malignancy there is a marked preponderance of females to males (10 to 2).

Site of origin.—On investigating the primary site of origin of the growth, i.e. whether primarily at the anal margin or in the anal canal, it seems clear that carcinoma of the anus is chiefly a disease of males (24 males to 5 females) and is of low and medium grade malignancy, whereas carcinoma of the anal canal is largely confined to females (23 females to 3 males) and is chiefly of medium and high grades of malignancy (Table III). This is shown graphically in fig. 4.

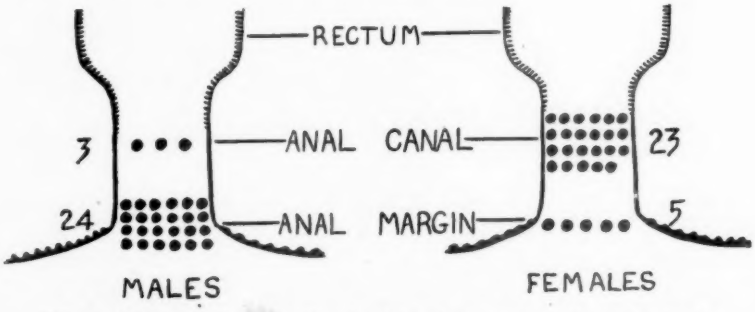

FIG. 4.—Diagram showing site of origin of squamous-cell carcinoma in males and females.

TABLE III.—SHOWING PRIMARY SITE OF GROWTH IN RELATION TO GRADE OF MALIGNANCY.

	Total number		Anal margin		Anal canal	
	Males	Females	Males	Females	Males	Female
Low grade	15	7	15	3	0	4
Medium grade	10	11	9	1	1	10
High grade	2	10	0	1	2	9
Total	27	28	24	5	3	23

It is somewhat speculative to attempt an explanation of this difference. The liability of men to carcinoma of the anus may be related to the undoubted fact that the male sex is the more liable to anal pruritus : Yeomans [4], for instance, puts the ratio of men to women as about 4 : 1. In addition to this there must be in any community a considerable number of men of the labouring class who habitually wear rough underclothing or rough working trousers next to the skin and are liable over a long period of years to repeated chafing of the anal and perineal skin. Fistula in ano is also a disease which is much more common in men. During the last five years, for example, 1935-39 inclusive, 391 cases of fistula in men have been admitted into St. Mark's Hospital compared with 140 women. Curtice Rosser [5] has described the ætiological importance of chronic fistula in ano in relation to the development of cancer of the rectum and anus.

In this series of 55 cases there are two undoubted examples, both in men, of a squamous carcinoma of the anus starting (1) in a very chronic fistula, and (2) in a region affected by chronic pruritus ani.

Case 42.—A man, aged 57, who was first seen with an extensive inoperable squamous carcinoma involving the buttocks, and region and anal canal. It was associated with chronic multiple fistulæ of thirty-seven years' duration and hitherto untreated. There was extensive malignant involvement of the glands in both groins. Biopsy proved the anal lesion to be a medium-grade squamous carcinoma. He was admitted into a Home for Incurables and died three months later.

Case 10.—A man, aged 60, with a severe chronic pruritus ani of many years' duration. X-ray treatment had been given three years previously. He attended at St. Mark's Hospital in October 1938, and a biopsy was done from an indurated hyperkeratinized patch without malignancy being proved. Local treatment was applied with much improvement, but in August 1939 he came up with a raised warty tumour measuring 1 × ¾ in. at the anal margin. It was proved microscopically to be a keratinizing squamous-cell carcinoma, of low-grade malignancy and was removed by perineal excision.

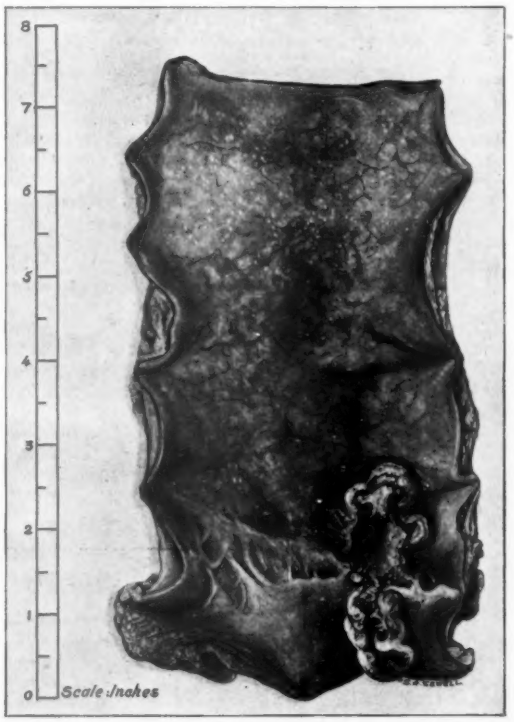

FIG. 5.—High-grade squamous-cell carcinoma of the anal canal, with a deep ulcer invading the prostate. Perineal excision; death from recurrence 14 months later.

The question why women rather than men should develop squamous carcinoma of the anal canal is difficult to answer. I can only hazard two suggestions :—

(1) Chronic constipation and fæcal impaction in the rectum is, I think, more common in women than men. Possibly the lodging of small fæcal masses in the anal crypts and the chronic irritation or trauma therefrom, might be of ætiological importance. The direction of the anal canal downwards and backwards might expose chiefly the anal valves and crypts *anteriorly* to repeated fæcal irritation and injury.

(2) Enlargement and prolapse of the right anterior primary internal hæmorrhoid is extremely common in women, and the growth of squamous epithelium over the lower pole of this hæmorrhoid is frequently met with. A third degree pile in this quadrant is liable to chronic surface irritation from clothing or sanitary pads, and the eventual development of a squamous-cell carcinoma here, on an inflamed and irritated surface, covered with new actively growing epithelium, would not be a surprising sequel.

Age according to the grade of malignancy.—It has already been shown that there is no significant difference between the average ages of the sexes, and it will be advisable now, for the sake of completeness, to show the average ages in the three grades of malignancy (Table IV).

TABLE IV.—AVERAGE AGE ACCORDING TO GRADE OF MALIGNANCY.

	Both sexes	Males	Females
Low grade	62·3	61·4	64·1
Medium grade	60·2	63·2	57·5
High grade	63·2	57·0	64·4

In the two male cases with high-grade carcinoma the growth occurred at an earlier average age than was the case in the other grades, but in females this difference is not seen. The average age of the 24 males with carcinoma of the anus was 62·5 years, whereas the average age of the 23 women with carcinoma of the anal canal was 60. This agrees with my personal experience that squamous carcinoma in women generally occurs at an earlier age than in men.

Quadrant affected.—I have endeavoured to ascertain if any particular quadrant of the anus or anal canal tends to be more liable to squamous carcinoma. In some cases where on admission the growth has been found to be very extensive or circumferential it has not been possible to define which quadrant was primarily affected, but in most cases this point has been settled. There appears to be a considerable preponderance of cases affecting the anterior quadrant, particularly in the anal canal. Out of the 29 cases of carcinoma affecting the *anal margin* 4 were circumferential, and 8 of the remainder, or one-third, were situated in the anterior quadrant. Out of 26 cases arising in the *anal canal*, 2 were circumferential and of the remainder 14, or one-half, were situated anteriorly. The clinical application of this is the frequency with which in females the posterior vaginal wall is involved and has to be removed when doing a perineal excision for carcinoma of the anal canal, and in men a deep malignant ulcer in the anterior part of the anal canal is in close and dangerous relationship with the bulb of the penis and the membranous urethra, and if the growth extends up into the rectum, with the prostate (fig. 5).

ASSOCIATED MALIGNANT DISEASE

Three women in this series developed carcinoma of the cervix.

Case 11.—A woman, aged 75, with a low-grade anal carcinoma treated with radium needles. Six months later she was found to have an extensive carcinoma of the cervix which was thought in all probability to have been present at the time of her previous rectal treatment.

Case 29.—This patient, aged 53 in 1924, survived for twelve years after colostomy and perineal excision. Uterine symptoms then developed and examination revealed a carcinoma of the cervix. Radium treatment was given for this but she died two years later from the uterine disease.

Case 50.—This patient, aged 59, had had a Wertheim's hysterectomy done thirteen months previously for carcinoma of the cervix. At the time of her rectal operation an ulcerating growth involved the *posterior* two-thirds of her anal canal. A perineal excision was done without difficulty and the rectum stripped off the vaginal wall; there appeared to be no connexion with the vaginal stump, nor was there any sign of recurrence of the cervical growth, so it was concluded that the anal carcinoma was probably independent.

That 3 women out of 29 should develop carcinoma of the uterine cervix before, coincident with, and twelve years after a squamous carcinoma of the anal canal is suggestive of a similar tendency to carcinoma in the epithelium of the cervix uteri and the anal region. The need for a general examination and regular supervision after operation is evident.

One other patient in this series (Case 22) had an advanced carcinoma of the anal canal and at the same time was observed to have a rodent ulcer of the face.

Diagnosis

There are no specific symptoms characteristic of anal carcinoma. Bleeding, discharge, pain, irritation, the presence of a lump at the anus, and difficulty in defæcation may all be present in varying degrees.

Pain is severe when a deeply ulcerating growth is present in the anal canal, and in the late stages much local inflammation and perhaps multiple fistulæ may be superadded. Involvement of the external sphincter not only causes pain but loss of normal control, and fæcal incontinence is another symptom of late and probably inoperable cancer.

Clinically, the suspicion that an anal carcinoma is present is aroused by finding an ulcer with an irregular indurated base as well as indurated slightly raised margins.

Very often, however, on account of pain and sphincter spasm it is difficult to pass a finger into the anal canal and to get any idea of the extent of the lesion. Examination under anæsthesia (usually a low spinal) is an essential part of the diagnosis and enables portions of a protuberant growth or the edge of an ulcer to be removed for microscopical examination, with a view to confirmation of malignancy and for grading.

In the differential diagnosis the following conditions have to be considered :—

(1) *Simple papilloma.*—An unusually large papilloma of the anus may give a feeling of induration at its base and constitute a difficult problem as to the correct procedure to adopt. The following case is an example of this :—

Case.—F. H., a man aged 51, was admitted into St. Mark's Hospital in 1923 under Sir Charles Gordon-Watson with a large papilloma of the anus extending up the anal canal : there were no glands in the groin. A colostomy was established and a piece of the tumour taken for biopsy : it showed a papilloma with an appearance of invasion of the deeper tissues by columns of epithelial cells, suggestive of an early squamous carcinoma : his Wassermann reaction was strongly positive. The tumour was then excised locally with division of part of the sphincter and a small recurrence needed local excision two months later. No further manifestation of recurrence was noted and the man finally died of bronchitis more than eight years later. A subsequent review of the sections resulted in the growth being classed as a benign papilloma.

An excellent example of a very large anal papilloma is illustrated by Lockhart-Mummery (" Diseases of the Rectum and Colon ", second edition, fig. 125).

(2) *Simple ulcer.*—In elderly subjects a chronic anal fissure may be found, in which the margins have become more than usually callous, slightly raised and perhaps a little irregular. In such a case there may very reasonably be a suspicion that an early squamous carcinoma has developed and a local excision of the lesion with a cutting diathermy followed by microscopical examination will clear up the diagnosis.

Hyperkeratinization round the external orifices of fistulæ may arouse a suspicion of malignancy. Two such cases treated at St. Mark's Hospital during this period were provisionally entered as possible early squamous carcinomas. Subsequent review of the sections has crystallized the view that they were non-malignant.

Another type of simple ulcer which deceived me on one occasion occurred in a woman, aged 67, who had previously been operated upon for a prolapse of the rectum, but recurrence of her symptoms had existed for about seven years : when examined in March 1938 she complained of anal soreness and bleeding for six weeks : examination showed an ulcer lying transversely at the anterior anal margin with raised indurated edges. It looked characteristic of an anal carcinoma and arrangements were made to admit her. When seen in the ward ten days later the ulcer was smaller and appeared to be healing at the margins ; in the course of another two weeks after simple local applications the ulcer had healed completely. The explanation was found to lie in the fact that for five months preceding her attendance at the hospital she had worn an apparatus with a solid rubber or vulcanite plug which was passed into the rectum to support her prolapse. Only when the ulcer caused intolerable pain did she give this up and the ulcer then quickly healed.

(3) *Chronic inflammation.*—A squamous-cell carcinoma arising in the upper part of the anal canal forms a problem which is difficult of solution until the passage of time indicates that the condition is a progressive one. The two following cases are, I think, very instructive ; they show the difficulties in this type and the necessity for review and examination under anæsthesia when it is apparent that the lesion is not clearing up on expectant treatment.

Case 1.—A lady, aged 75, complained of anal pain and of a frequent desire to go to the W.C. Examination showed an extreme contraction of the external sphincter so

that only a little finger could be inserted; a chronic indurated fissure in the right anterior anal quadrant was present. At operation the fissure was excised and the subcutaneous external sphincter divided. A submucous induration was then found in the right lateral quadrant of the anal canal in its upper part, suggestive of a recent thrombosis. It was incised and what appeared to be a representative piece of tissue sent for microscopical examination was found to show no sign of malignancy. The fissure wound duly healed and all went well until three and a half months after operation when the patient returned complaining of anal discomfort without bleeding. Digital examination showed that the fissure was healed but the passage of a finger caused bleeding, and a flat induration could be felt at the upper end of the scar in the anal canal. Examination under anæsthesia clearly indicated clinically that this was a malignant growth, ? squamous, ? columnar, and a portion removed proved it to be a cellular squamous-cell carcinoma.

Case 2.—Patient, female, age 63, was recently admitted into St. Mark's Hospital under the care of Mr. L. E. C. Norbury. In June and July 1939 she was given two injections for hæmorrhoids in the Out-patient Department. In September-December 1939 she complained of anal pain and what appeared to be a thrombosis was found in the left lateral pile previously injected. This condition persisted, with pain and slight bleeding, and it was finally decided to admit her. In July 1940 examination under low spinal anæsthesia was done, and an indurated mass the size of a large walnut was found in the submucous and perirectal tissues in the left anterior quadrant: there was no overlying ulceration. An incision was made into it for purposes of biopsy, and a squamous-celled carcinoma of medium grade malignancy was proved to be present.

(4) *Tuberculous ulcer.*—As is well known the characteristic feature of a tuberculous anal ulcer is undermining of the edges, which are almost invariably thin and impalpable with a finger. A flat malignant ulcer in the anal region may sometimes somewhat resemble a tuberculous lesion, and when searched with a probe a slight undermining of the margins, due here to the more active peripheral growth, may be demonstrated. Such a carcinomatous ulcer will, however, always have slightly indurated margins which should arouse the suspicion of malignancy. The age of the patient is also significant, a tuberculous ulcer usually occurring in subjects of 30 or under with active pulmonary tuberculosis, while squamous carcinoma of the anus develops at a much later average age (62·5 years in males).

(5) *Tuberculide.*—The raised hyperplastic form of anal tuberculosis is characterized by an irregular indurated lesion of extreme chronicity, without infection of the inguinal glands. I have one such case under observation at the present time. It is seen as a much more superficial and diffuse lesion than is likely to be caused by squamous cancer: when, however, a tuberculide occurs as a more circumscribed lesion the resemblance is much closer and the diagnosis may have to be settled by the microscope, either by removing a wedge from the margin or by excising the whole lesion by the cutting diathermy and sending it for section.

(6) *Primary chancre.*—This is characterized by the presence of a raised indurated lesion at the anal margin with some surface ulceration. The diagnosis from anal carcinoma is readily made by the *short history* (average duration about three weeks), and the presence of a *very marked tender inguinal adenitis.* A search for spirochætes should give immediate confirmation and the Wassermann reaction will be strongly positive.

(7) *Amœbic ulcer.*—This rare form of ulceration affecting the lower rectum and anal region must be borne in mind when the patient is known to have been abroad, whether there is a history of dysentery or not. The case (previously reported to this Section, *Proc. Roy. Soc. Med.*, 1939, **32**, 902), was characterized by extreme emaciation which at first suggested that the condition was an advanced anal carcinoma, but against this was the absence of induration at the margins of the ulcer, the very extensive ulceration and sloughing of the tissues and absence of enlarged inguinal glands. The successful search for cysts of *Entamœba histolytica* and the truly remarkable improvement after a week's course of emetine clearly proved that the case was an example of amœbic ulceration.

(8) *Basal-cell carcinoma.*—I have met with only one example of a basal-cell carcinoma in the anal region.

Case.—The patient was a stout man, aged 70, who was sent to me in March 1938, by my colleague, Dr. Henry Semon, with a diagnosis of rodent ulcer already established by section. He presented an oval flat ulcer the size of a thumb-nail in the right posterior anal quadrant, well external to the anal margin. He had had this for about two years and I had seen him previously in July 1936, when he had a small superficial ulcer, 0·5 cm. in diameter, associated with pruritus and multiple peri-anal excoriations. I suggested painting this with mercurochrome, or Friar's balsam, which was tried for a time without much effect, and in the autumn of 1937 he was given some X-ray treatment.

The ulcer slowly increased in size and its progressive nature led to a biopsy being done, and the correct diagnosis was established. The remarkable features of this ulcer from the clinical point of view were its extremely superficial nature, and the absence of a palpable edge or induration. I excised the ulcer locally with a cutting diathermy and left a triangular shaped wound to heal by granulation. He was quite well and had a perfect soft scar a year later.

(9) *Columnar-cell carcinoma.*—Invasion of the anal canal and anal margin by a columnar-celled carcinoma of the rectum can readily be proved by biopsy and this is really the only certain method of distinguishing it from a squamous carcinoma of the anal region. Extreme local tenderness usually prevents adequate clinical examination, and even after examination under anæsthesia the matter is usually in doubt until the microscopical sections are available. An extremely hard growth is perhaps more likely to be squamous, although exceptions are numerous. A very soft growth at the anus, especially if there is any suspicion of colloid material being observed after a digital examination, is more likely to be an adenocarcinoma.

Treatment

The treatment of squamous-cell carcinoma of the anus is a difficult problem which is accentuated by the rarity of the disease as compared with adenocarcinoma of the rectum, so that few surgeons can expect to have a great personal experience of it. In order, at any rate, to report what has been achieved at St. Mark's Hospital over a period of eighteen years and to see what lessons can be drawn from our experiences, I have endeavoured to set out our results in the following way, arranged according to (1) the grade of malignancy, (2) the stage of the disease, (3) the main line of treatment.

(1) The grade of malignancy—low, medium or high grade—needs no further explanation.

(2) The stage of the disease: I have on a clinical basis classified the cases as "early" or "late", according to the size of the growth and extent of spread. For instance, a localized flat, nodular or ulcerated growth up to about 1½ in. in diameter, involving one quadrant of the anal canal or anal margin, has been assessed as *early*, whereas a growth described in the notes as "a large epithelioma of the anus, completely surrounding the anus and not admitting a finger", or "an extensive epithelioma of the anus, involving the perineum, buttock and scrotum", has been assessed as a *late* case.

(3) Some of these cases have had several treatments. This has occurred particularly in the late cases, in which perhaps radium treatment has been given first, and later, by reason of recurrence or insensitivity, it has been followed by another implantation of radium or by some other form of attack, such as diathermy excision or X-ray therapy. In such a case the first treatment is, I think, the essential one and it is on this that the case has been classified.

Perusal of Table V will enable the recent cases and the inoperable cases to be segregated. In each grade of malignancy where a number of cases have been treated by a similar method such as radium or perineal excision they have been arranged in chronological order, and the ultimate result has been ascertained in every case. With this table available my analysis of our end-results can be considerably curtailed and only a few cases will need to be mentioned in detail.

Low-grade malignancy.—The proportion of early to late cases in this group is 10 to 12. It is apparent at once that the most consistently good results have been obtained in the *early* cases of low-grade squamous carcinoma. Eight cases were treated by radium needling without colostomy and without an inguinal gland dissection; five patients are now alive and free from recurrence for periods ranging from ten to four years. Two patients died from intercurrent disease more than three years after radium treatment, and one man of advanced age, though there was no recurrence, became depressed and committed suicide recently, four years and four months after his radium treatment.

The method of interstitial radium needling used in these cases has been fully described by Sir Charles Gordon-Watson [6], and I need not refer to any details of technique; the dose has varied from about 1,000 to 3,700 mgm. hours according to the size of the lesion.

In reporting these results I do not want to give the impression of suggesting that radium needling is the only treatment to be recommended for an early squamous carcinoma of the anus. In such cases the lesion is generally of a low grade of malignancy and is readily accessible for treatment. If a series of such cases were treated by a local excision

TABLE V.—SUMMARY OF RESULTS IN 55 CASES OF SQUAMOUS-CELL CARCINOMA OF THE ANUS AND ANAL CANAL, CLASSIFIED ACCORDING TO GRADE OF MALIGNANCY, CLINICAL STATE AND TREATMENT.

No. of case	Grade of malignancy	Site of growth	Clinical state	Initials	Sex	Age	Treatment	Date of treatment	Result	Cause of death
1	Low grade	A.M.	Early	H. C.	M.	71	Radium	Oct. 1929	Died July 1933	Senility and myocardial degeneration
2	„	A.M.	„	C. W.	M.	70	„	Oct. 1930	A. & W. Dec. 1940	
3	„	A.M.	„	J. A.	M.	59	„	April 1932	A. & W. June 1940	
4	„	A.M.	„	A. S.	F.	72	„	Jan. 1933	„	
5	„	A.M.	„	D. P.	M.	71	„	May 1933	Died July 1936	Probably intercurrent disease
6	„	A.C.	„	A. N.	F.	59	„	Sept. 1933	A. & W. Dec. 1940	
7	„	A.M.	„	S. B.	M.	69	„	April 1936	Died Aug. 1940	Suicide, no recurrence
8	„	A.M.	„	J. R.	M.	64	„	Dec. 1936	A. & W. Dec. 1940	
9	„	A.M.	„	H. C.	M.	41	Local excision with diathermy	Sept. 1938	„	
10	„	A.M.	„	J. B.	M.	60	Colostomy and perineal excision	Oct. 1939	„	
11	„	A.M.	Late	L. S.	F.	75	Radium	Dec. 1928	Died early 1930	Recurrence, also carcinoma of cervix uteri
12	„	A.M.	„	A. W.	M.	72	Colostomy, then radium	Feb. 1929	Died Feb. 1930	Recurrence
13	„	A.M.	„	S. S.	M.	50	Radium	Feb. 1929	A. & W. June 1940	
14	„	A.M.	„	C. B.	M.	67	„	April 1930	Died Feb. 1931	Recurrence locally and in groins
15	„	A.M.	„	G. K.	F.	56	„	Sept. 1930	Died Sept. 1931	Recurrence
16	„	A.M.	„	T. S.	M.	45	„	July 1934	Died May 1935	Recurrence locally and in groins
17	„	A.C.	„	M. P.	F.	59	Colostomy and perineal excision	Feb. 1923	Died Jan. 1927	Recurrence in buttock
18	„	A.M.	„	F. B.	M.	54	„	Oct. 1924	A. & W. Dec. 1940	
19	„	A.M.	„	J. B.	M.	51	„	June 1925	Died June 1929	Recurrence in groin
20	„	A.M.	„	I. C.	M.	77	„	Sept. 1937	A. & W. May 1940	
21	„	A.C.	„	E. Y.	F.	62	Perineo-abdominal excision	May 1931	Operative death	Sepsis
22	„	A.C.	„	A. L.	F.	66	Colostomy (refused excision)	June 1932	Died Feb. 1934	Extension of disease
23	Medium grade	A.C.	Early	B. R.	F.	59	Colostomy, then radium	Nov. 1931	Died Oct. 1935	Intercurrent disease
24	„	A.M.	„	S. P.	M.	50	Radium	Oct. 1934	Died Aug. 1935	Recurrence
25	„	A.M.	„	F. H.	F.	69	„	Aug. 1935	Died June 1937	Recurrence
26	„	A.C.	„	F. W.	F.	55	„	May 1938	Alive Dec. 1940 with recurrence	
27	„	A.M.	„	A. R.	M.	54	Local excision with diathermy	Oct. 1934	Died Feb. 1939	Recurrence in groins

28	„	A.M.	„	H. P.	M.	58	„	April	1938	A. & W. Dec. 1940	
29	„	A.C.	„	A. C.	F.	53	Colostomy and perineal excision	July	1924	Died May 1938*	Carcinoma of cervix uteri
30	„	A.C.	Late	E. B.	F.	54	Colostomy, then radium	Oct.	1928	Died Dec. 1931	Recurrence locally and in groins
31	„	A.M.	„	J. T.	M.	70	Radium	March	1930	Died March 1932	Broncho-pneumonia (no recurrence)
32	„	A.M.	„	J. Y.	M.	77	Radon	Aug.	1931	Died Oct. 1934	Recurrence locally and in groin
33	„	A.C.	„	N. P.	F.	70	„	Oct.	1932	Operative death	Cellulitis
34	„	A.M.	„	G. F.	M.	73	Radium	May	1934	Died Sept. 1935	Recurrence
35	„	A.M.	„	C. T.	M.	75	Colostomy, then radium	Oct.	1934	Died Oct. 1936	Recurrence
36	„	A.M.	„	E. P.	M.	66	Radium	Nov.	1936	Alive Dec. 1940 with recurrence	
37	„	A.C.	„	R. S.	F.	65	„	June	1937	A. & W. Dec. 1940	
38	„	A.C.	„	S. H.	F.	63	„	July	1940	„	
39	„	A.C.	„	M. H.	F.	69	Colostomy and perineal excision	Sept.	1928	A. & W. Dec. 1940*	
40	„	A.C.	„	E. G.	F.	44	„	Sept.	1936	Died May 1937	Pyelonephritis (no recurrence)
41	„	A.C.	„	C. C.	M.	52	Palliative colostomy	Feb.	1933	Died August 1933	Extension of disease
42	„	A.M.	„	H. D.	M.	57	Expectant (late, inoperable)	July	1936	Died Oct. 1936	Extension of disease
43	„	A.C.	„	G. W.	F.	31	Expectant (refused operation)	June	1937	Untraced	
44	High grade	A.C.	Early	C. C.	F.	65	Radium	July	1934	Died Aug. 1937	Recurrence
45	„	A.C.	„	S. L.	F.	71	„	July	1936	Died April 1937	Secondaries in lungs
46	„	A.M.	„	M. B.	F.	75	Local excision	Dec.	1937	Died March 1939	Stroke and senile decay
47	„	A.C.	„	L. B.	F.	64	Colostomy and perineal excision	Oct.	1936	Died Dec. 1937	Recurrence in perineum
48	„	A.C.	„	E. K.	F.	74	„	Aug.	1938	Operative death	Sepsis and chest complications
49	„	A.C.	„	M. G.	F.	46	„	Nov.	1938	Operative death	Uræmia
50	„	A.C.	Late	E. V.	F.	59	„	Feb.	1928	Died May 1928	Cardiac failure
51	„	A.C.	„	L. C.	F.	61	„	May	1934	A. & W. Dec. 1940*	
52	„	A.C.	„	C. L.	M.	52	„	Dec.	1934	Died Nov. 1936	Recurrence
53	„	A.C.	„	R. P.	M.	62	„	Oct.	1936	Died Dec. 1937	Recurrence in perineum
54	„	A.C.	„	S. B.	F.	69	„	May	1940	A. & W. Dec. 1940	
55	„	A.C.	„	F. N.	F.	60	Expectant (late, inoperable)	April	1937	Died May 1937	Extension of disease

Note.—A.M. = Anal margin.
A.C. = Anal canal.
A. & W. = Alive and well.
The * marks the 3 five-year survivals in the medium and high grades of malignancy.

with diathermy, equally good results might be obtained. For instance, we have in this series the case of a man, aged 41 (Case 9), with an ulcerated low-grade squamous carcinoma at the anal margin who was treated by local excision of the lesion with a cutting diathermy, the section being carried fairly deeply, with removal of part of the external sphincter ani (fig. 6A). He has now passed the second anniversary of his operation without recurrence and with an excellent functional result (no colostomy).

We have had no opportunity at St. Mark's Hospital of giving either high or low voltage X-rays or for radium bomb therapy, and consequently I cannot offer any opinion as to the value of these methods in the treatment of carcinoma of the anus.

FIG. 6A.—Early squamous carcinoma of the anus (low grade) in a man aged 41 (Case 9). Excised locally with cutting diathermy, September 1938; alive and well 2 years later. No gland dissection required.

Of the *late cases*, 12 in number, six were treated by radium needling with one good result. This case, treated by Mr. E. T. C. Milligan, was illustrated by Sir Charles Gordon-Watson in 1930 and the details briefly are as follows:—

Case 13.—The patient was a man, aged 50, with an extensive ulcerated growth involving the left side of the anus; there were no palpable glands in the groin. Interstitial radium needling was carried out in February 1929, the dose being 10 mgm. radium for ten days = 2,184 mgm. hours. In October 1929 radium was inserted into both groins as a prophylactic measure. The patient remains perfectly well, and has had no further treatment.

The remaining five cases treated by radium needling died after short intervals, either unrelieved or with recurrence.

Of the four cases treated by colostomy and perineal excision, two survived for four years and finally died of recurrence. One man, aged 54 (Case 18), with a large fungating tumour completely surrounding the anus has been cured for sixteen years (Sir Charles Gordon-Watson's case).

The fourth case treated by colostomy and perineal excision is, I think, distinctly encouraging. He was a man, aged 77 (Case 20), with a very extensive growth which had completely destroyed the anus and formed a large ulcer extending out on to the left buttock. A perineal excision was done with a cutting diathermy knife and has produced a good result with no sign of recurrence locally or in the groins just over two and a half years later. I do not believe that any other treatment would have proved so satisfactory.

Medium-grade malignancy.—In this group the early cases are in a marked minority to the late cases, in the proportion of 7 to 14.

Four of the early cases were treated with radium with two good results.

Case 23.—A woman, aged 59, with a nodular and ulcerating growth in the anal canal, treated in November 1931 by interstitial radium needling (28 mgm. : dosage 4,592 mgm. hours). The growth completely disappeared, but two years later (September 1933) she developed an enlarged gland in the right groin. A gland dissection was then done, and the gland was proved to be infiltrated with squamous carcinoma. She remained well for another two years, and then died almost certainly without recurrence.

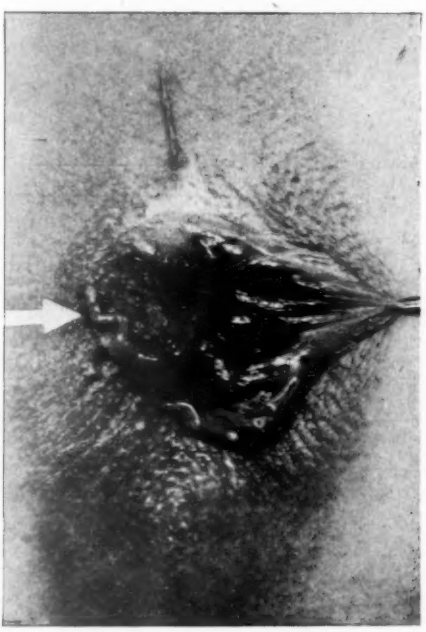

FIG. 6B.—Early squamous carcinoma of the anus (medium grade). Male, aged 58 (Case 28). Excised locally with cutting diathermy, April 1938; alive and no recurrence, December 1940. No gland dissection required.

Two cases (24 and 25) proved to be extremely radio-resistant and died from the disease in spite of subsequent X-ray therapy, and diathermy excision followed by X-ray therapy respectively.

In one other patient (Case 26) a deep malignant ulcer in the anal canal eventually healed after radium treatment, but two years later a slow recurrence invading the sacrum began to manifest itself.

The three early cases treated by excisional surgery have done fairly well:—

Case 27.—This man, aged 54, had a flat ulcerating squamous carcinoma involving the anterior anal margin and peri-anal region. In July 1934 it was excised with a cutting diathermy knife and the wound well cauterized with coagulating diathermy. Three months later, on account of a slight suspicion of local recurrence, a radium needling was done, the dose being 2,700 mgm. hours. He remained well, with no sign of recurrence, until March 1936. An interval of more than six months then elapsed before his next attendance and when he was next examined in October 1936 glandular metastases were evident in both groins. A block dissection of the glands of both groins was done and metastases were proved to be present on each side. Towards the end of 1938 œdema of the thighs, penis and scrotum began to develop and he died in February 1939, probably with extension of the disease to the external iliac glands and abdomen.

Case 28.—This man had a nodular growth 1 in. in diameter at the anal verge and extending into the anal canal. It was excised locally with diathermy in April 1938, together with part of the external sphincter. The patient has remained well for two and a half years; he is free from recurrence and there has been no indication for doing a gland dissection of the groin on the affected side (fig. 6B).

Case 29.—A female, aged 53, with a friable growth in the anal canal involving the vagina. Colostomy and perineal excision was done in July 1924, the lower part of the posterior vaginal wall being removed with the growth. She remained in good health for twelve years until in 1936 she noticed vaginal discharge and backache. Examination proved her to have a carcinoma of the cervix which was treated by radium with temporary improvement, but it caused her death two years later.

Taking now the *late* cases of medium-grade malignancy it will be seen that nine were treated with radium, with one operative death from cellulitis. Four cases have died from recurrence and one (Case 31) survived for two years and died from bronchopneumonia without evidence of recurrent carcinoma.

There has been one good result as follows:—

Case 37.—A woman, aged 65, with a large malignant ulcer involving the right side of the anus, extending up the anal canal to above the ano-rectal ring, also forwards to the right labia and the posterior vaginal wall. Enlarged inguinal glands were present in both groins. In June 1937 an interstitial radium needling was carried out (30 mgm. for six days = 4,248 mgm. hours). A month later a gland dissection of both groins was done, metastases being found in one gland on the left side. The patient remains well and so far as can be judged from her report and that of her doctor no recurrence has taken place (Mr. Milligan's case).

One other case, although probably now recurring, has done remarkably well in spite of a very extensive disease at the time of treatment:—

Case 36.—A man, aged 66, with a hard raised growth in front of the anus extending over the bulbous urethra, with an ulcerated area in the anal canal extending upwards to above the prostate. In November 1936 he was treated by interstitial needling followed by two intrarectal insertions of radium, to the total dosage being 6,048 mgm. hours. Two years later his health was stated to be good although perineal pain was troublesome. A recent report is that he is still alive and in fair health, but having much pain: a sinus is present ? recurrence (Mr. Milligan's case).

Two late cases of medium-grade malignancy were treated by colostomy and perineal excision. One died within a year from pyelonephritis, and the other remains alive and well twelve years later.

Case 39.—A woman, aged 69, with an extensive ulcerating growth involving the anterior aspect of the anus and anal canal. It was adherent to the posterior vaginal wall which was removed in the course of the perineal excision. There has been no recurrence and no further treatment in the twelve years that have elapsed since then.

High-grade malignancy.—These cases are 12 in number, 6 being in the early stage clinically and 6 late cases.

Radium treatment was given to two early cases with satisfactory immediate response and for about two years there was an apparent cure. Then signs of recurrence began to be in evidence and the patients died about three years after the original treatment, one having signs of secondary deposits in the lungs.

Four early cases were treated by excisional methods. One patient (Case 46) presented a large anal tag in the right posterior quadrant, with an irregular ulcerated area on it 1 in. in diameter. Mr. O. V. Lloyd-Davies treated this by a local excision including portions of the subcutaneous and internal sphincters in relation to the right posterior

hæmorrhoid which was ligated. Six months later the patient (aged 75) had a stroke and finally died of senile decay, without evidence of recurrence, fifteen months after operation.

Of the three early cases treated by colostomy and perineal excision two were operative deaths and the other developed cutaneous recurrences in the perineum from which she died a little over a year after operation.

Considering now the six late cases of high-grade carcinoma, it will be seen that five were treated by colostomy and perineal excision: one died of sudden cardiac failure while convalescing, two died of recurrence, and one is recent. The only case which has done well is of some interest surgically.

Case 51.—The patient was a woman, aged 61, with a deeply ulcerating growth in the lower third of the rectum invading the posterior vaginal wall. Colostomy and perineal excision, with removal of a portion of the posterior vaginal wall in continuity with the growth, was carried out in May 1934. A year later she developed a recurrent nodule at the lower end of the vagina posteriorly, and the problem was whether to treat this with radium or diathermy. I decided to excise it widely with a cutting diathermy (May 1935); the wound was left open and it healed by granulation. Histological examination showed that the tissue removed was infiltrated with squamous carcinoma During the five years that have since elapsed the patient has kept well and there has been no recurrence; the inguinal glands have been watched and there has at no time been any indication for doing a gland dissection.

Management of the inguinal glands.—No case of metastasis to the inguinal glands has occurred in the low-grade squamous carcinomas in this series when they were first seen and treated in the early stage. In the late low-grade cases and in the medium and high grades, metastases have been met with at the time of the primary treatment and subsequently.

The necessity for a gland dissection of the groins must be decided on clinical grounds. If the glands are enlarged to about ½ in. diameter or more, if they are hard rather than firm or soft, metastases are probably present and a block dissection should be done of one or both groins according to indications. In my opinion the best time for a gland dissection, if there is an immediate indication for this, is two or three weeks after the treatment of the primary growth has been carried out.

Two points in technique and management might be mentioned. After the limits of the dissection have been marked out and the external oblique and the iliac portion of the fascia lata defined, the glands and surrounding fat are swept towards the saphenous opening. Then, working from below upwards, the internal saphenous vein should be defined and divided between thread ligatures two or three inches below the saphenous opening. The vein is dissected up and finally ligated flush with the femoral vein as when doing a Trendelenburg's operation. A clean sweep of the glands and fat to just within the crural canal can then be effected.

The slow healing of these wounds is notorious. I believe the best way of maintaining the nutrition of the flaps and preventing them from becoming lifted up by serum is to leave the central third of the wound unsutured; efficient drainage is thus provided without any need for rubber drains. The wound is dressed daily with flat gauze packs moistened with eusol and bandaged on firmly. On these lines I have seen healing almost complete in less than three weeks.

I am opposed to the local removal of a gland for diagnostic purposes; if the glandular enlargement is such as to arouse the suspicion of malignancy the only sound treatment is a formal gland dissection. If no glands are palpable in the groins or if only small, clinically simple glands are present, the groins should be watched, and I must emphasize the importance of this supervision for at least two and a half years after operation. The patient's own report cannot be accepted as accurate, and he or she should be strictly enjoined to attend for review every month for the first six months and then every two months until all danger of lymphatic spread has passed. If longer intervals are allowed to elapse the patient may be found to have developed irremovable glands which might have been tackled if they had been diagnosed earlier. Following radium treatment to the anal growth, if there is any clinical suspicion of recurrence, an extra and close watch must be kept on the groins for this is the stage when lymphatic extension often seems to occur rapidly.

Results of treatment.—The cases submitted to radium or excisional surgery prior to

September 1935 are shown in Table VI grouped into the three grades of malignancy. As the numbers are small the medium and high grade cases have been bracketed together to give comparable numbers.

TABLE VI.—SHOWING SQUAMOUS-CELL CARCINOMA OF THE ANUS AND ANAL CANAL ON A FIVE-YEAR BASIS.

	Number submitted to radium treatment or excisional surgery		Five-year survivals		Percentage
Low grade ...	15		6		40
Medium grade ...	11	15	2	3	20
High grade ...	4		1		
Total	30		9		30

The prospects of cure in the low grade of malignancy appear to be exactly double those of the combined medium and high grades: out of 15 low-grade cases six reached the

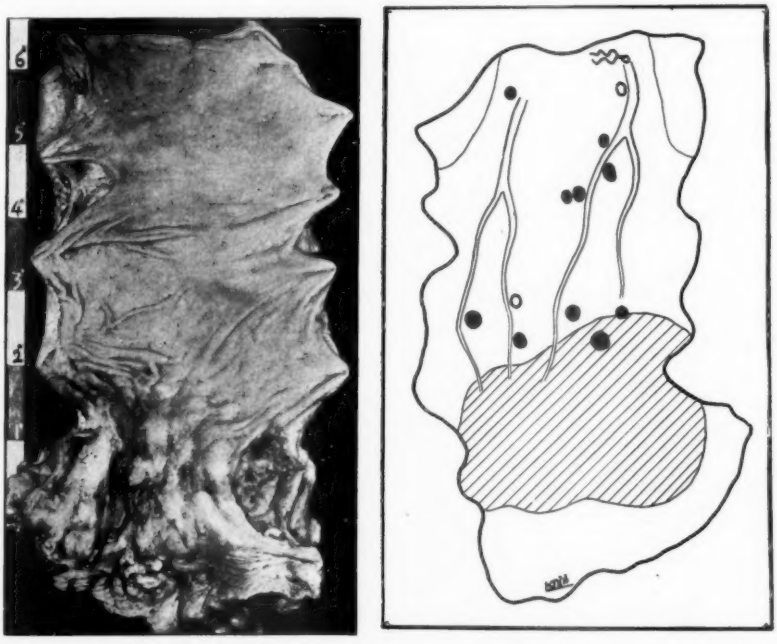

FIG. 7.—Extensive high grade squamous carcinoma of the anal canal (Case 54), removed by colostomy and perineal excision. The growth completely encircled the anal canal and the lower part of the rectum. Metastases were present in ten superior hæmorrhoidal lymphatic glands.

five year period without recurrence (40%), whereas out of fifteen medium and high grade cases only three survived (20%). These have been marked in Table V with a *, and it is seen that a perineal excision was responsible for the good result in all three cases.

Gilchrist and David [7] have reported a case of squamous-cell carcinoma which had extended up the anal canal to beneath the rectal mucosa, with metastases in the meso-rectal glands. They advise a radical excision of the rectum whenever a squamous carcinoma has involved the rectal mucosa. Our cases at St. Mark's Hospital support this

view. Excision of the rectum for squamous carcinoma was done in 17 cases in this series. Six were of low-grade malignancy with no case in which the meso-rectal glands were involved, three were of medium grade with one case of upward lymphatic spread, and eight were of high-grade malignancy of which three had metastases in the meso-rectal lymphatic glands. Although only one (fig. 7) of these patients is now alive (recent operation in May 1940) it is evident that this type of growth tends to spread widely locally and via the rectal lymphatics. It does not seem likely that satisfactory radiation could be applied by radium over so extensive an area, and unless it is shown that X-ray therapy can be given efficiently in this very sensitive region both to the primary growth and to the lymphatic spread, I consider that these anal canal growths should be treated surgically by an extended perineal excision of the rectum. An extra wide sweep of the peri-anal skin and ischiorectal fossæ should be taken, and the use of the cutting diathermy knife is the method of choice for the preliminary stages of the operation.

If the growth has become ulcerated on to the skin at the time of operation it would appear reasonable to minimize the risk of implantation recurrence by thoroughly swabbing or irrigating the wound surfaces with perchloride lotion at the end of the operation, as recommended by Sampson Handley in the case of radical mastectomy for breast carcinoma.

One other point may be worth mentioning. There appears to be an abnormal incidence of wound sepsis after perineal excision for squamous carcinoma. This may be due to the fact that it is often impossible to close the anus properly by suture when the growth has ulcerated on to the anal region. I would suggest that the prophylactic use of the sulphonamides, both locally and orally, might be tried in these cases.

I am indebted to all my colleagues at St. Mark's Hospital for allowing me to collect their cases together and embody their results in this report. I am grateful to Mr. O. V. Lloyd-Davies for lending his experience in the grading of squamous carcinomas, and most of all to Dr. Cuthbert Dukes for his generous and invaluable co-operation in this task, for selecting the sections to illustrate the three grades of malignancy and for various much-appreciated suggestions. To Mr. H. J. R. Bussey I am much indebted for the photomicrographs and the other photographs which he has prepared in the Pathological Department of St. Mark's Hospital.

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Ronald W. Raven, F.R.C.S.—Cases of carcinoma of the anus and anal canal admitted to The Royal Cancer Hospital during the years 1929 to 1940 inclusive have been studied. Those not proved by microscopic examination and cases of columnar-cell carcinoma were rejected from this series leaving a total of 19 for study. There were 9 males and 10 females with an age range from 34 to 78 years, the average being 58 years. The disease has a relatively short history of symptoms, the average duration was nine months. The cases were classified into two stages: Stage I—inguinal lymph nodes not palpable (3 cases) Stage II—inguinal lymph nodes palpable (16 cases). The methods of treatment employed are set out in Table I. The results obtained in each case are set out in Table II. Attention is called to certain methods of treatment with irradiation in these cases.

(1) Teleradium therapy: A successful result was obtained in the case of a man with a papilliferous carcinoma arising from the anal verge and surrounding the anal orifice; the inguinal lymph nodes on both sides were enlarged. Biopsy of growth showed a squamous-cell carcinoma. Teleradium therapy was given to the primary growth and both inguinal regions, dose 48,000 mgm. hrs. to primary, 76,000 mgm. hrs. to groins. No colostomy was necessary. The patient is alive without recurrence four and a half years later. The condition before and after treatment is shown in figs. 1 and 2.

(2) Low-voltage contact therapy (Chaoul). An encouraging result was obtained in the case of a woman with an ulcerating carcinoma 7 × 6 cm. arising from the right side of the anus and extending on to the right buttock with enlarged lymph nodes in both groins. Biopsy of ulcer showed a squamous-cell carcinoma. Low-voltage contact therapy was given to the primary lesion, dosage 6,000 r max. and 5,400 r min. in twelve days and high-voltage therapy to both groins, dosage 3,100 r max. and 2,480 r min. in thirty-two days. The treatment was carried out one year ago and the result is shown in figs. 3 and 4.

(3) Combined surgical and radiological methods may be employed in certain cases with advantage as illustrated in the case of a man with a carcinoma involving the

FIG. 1.—Carcinoma of the anus before teleradium therapy.

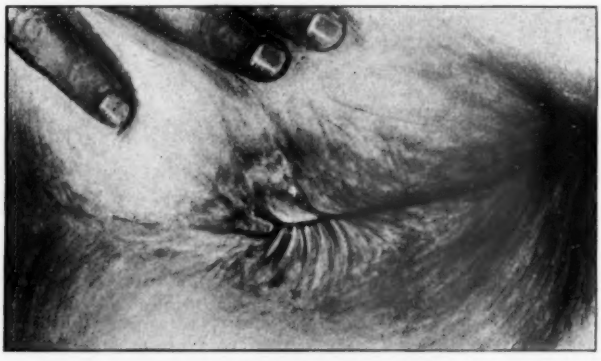

FIG. 2.—Carcinoma of the anus after teleradium therapy. (Four and a half years later.)

posterior wall of the anal canal and protruding from the anal orifice with enlarged, hard, fixed lymph nodes in both groins. Treatment was as follows: (*a*) Low-voltage contact therapy to primary growth, dosage 4,800 r and teleradium to both groins, dosage 14,400 r. Improvement occurred in both the primary growth and regional lymph nodes; (*b*) five months later interstitial radium needles to primary growth, dosage 80¼ mgm. hrs.; (*c*) Two months later there was a residual small ulcer on the left postero-lateral wall of the anal canal; no enlarged lymph nodes were present in groins. A perineal excision

of the rectum was performed. Microscopical examination before treatment showed a squamous-cell carcinoma; after excision no carcinoma cells were seen. This patient survived twenty-nine months from the beginning of the first treatment, and died from recurrent carcinoma in the groins and skin of scrotum.

With regard to the treatment of the regional lymph nodes in the groins it is advisable to treat all cases whether the nodes are palpable or not with either teleradium or high-voltage X-rays.

I acknowledge the kindness of my colleagues at the Royal Cancer Hospital for allowing me to study this material.

FIG. 3.—Carcinoma of the anus before low-voltage contact therapy. (Mr. Abel's case.)

FIG. 4.—Carcinoma of the anus after low-voltage contact therapy. (Mr. Abel's case.) (One year later.)

TABLE I.—SQUAMOUS-CELL CARCINOMA OF ANUS AND ANAL CANAL—METHODS OF TREATMENT.

(1) *Of primary growth.*

(*a*) *Excisional surgery.*

(i) Local excision of carcinoma.
(ii) Perineal excision of rectum.
(iii) Abdomino-perineal excision of rectum.

(*b*) *Irradiation therapy.*

(i) Intracavitary irradiation with radium applicator.
(ii) Interstitial irradiation with radium needles.
(iii) Teleradium.
(iv) Low-voltage (60 kV.) X-ray therapy (Chaoul therapy).

(*c*) *Combined treatment.*

Irradiation followed by excision.

(2) *Of regional lymph nodes.*

(i) Teleradium.
(ii) High-voltage X-ray therapy.

TABLE II.—SQUAMOUS CARCINOMA OF ANAL CANAL AND ANUS—RESULTS OF TREATMENT.

Case	Sex and Age	Stage	Duration of symptoms in months	Treatment	Survival period in months	Alive or dead	Cause of death
H. S.	M. 59	I	3	(*a*) Radium applicator (*b*) Radium needles	7	Dead	Intercurrent disease
J. M.	M. 66	I	4	Colostomy and perineal excision of rectum	56	Alive	
E. K. H.	F. 53	I	12	Abdomino-perineal excision of rectum	96	Alive	
A. E. D.	M. 53	II	9	(*a*) Colostomy and diathermy excision (*b*) Teleradium to anus and groins	7	Dead	Cancer
H. W. C.	M. 62	II	12	Colostomy and teleradium	6	Dead	Cancer
J. E. S.	M. 49	II	6	(*a*) Chaoul therapy, anus; teleradium, groins (*b*) Radium needles to anus (*c*) Perineal excision of rectum	29	Dead	Cancer
F. H.	M. 57	II	7	Teleradium anus and groins	54	Alive	
A. S.	M. 77	II	4	(*a*) Excision (*b*) Diathermy excision (*c*) H.V. X-ray therapy, groins	36	Dead	Cancer
F. D. H.	M. 78	II	2	Radon seeds to growth	0	Dead	Intercurrent disease
F. H. P.	M. 34	II	3	Colostomy	4	Dead	Cancer
M. C. C.	F. 72	II	3	Colostomy and local excision	71	Dead	Cancer
B. S. P.	F. 65	II	2	(*a*) Chaoul therapy, anus (*b*) H.V. X-ray therapy, groins	12	Alive	
S. V.	F. 71	II	48	Teleradium (incomplete)	—	Untraced	
E. F.	F. 57	II	12	Perineal excision	0	Dead	Intercurrent disease
M. L. M.	F. 46	II	6	Perineal excision	2	Dead	Cancer
M. H.	F. 71	II	5	(*a*) Radium applicator (*b*) Colostomy	11	Dead	Cancer
F. V. P.	F. 55	II	17	Colostomy and radium needles	4	Dead	Cancer
S. F.	F. 65	II	12	Colostomy and diathermy excision	2	Dead	Cancer
L. S.	F. 49	II	4	Palliative	4	Dead	Cancer

Section of the History of Medicine

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A Medico-Psychological Revision of the Story of Jehanne, la Pucelle de Domrémy

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It has been wittily said that history does not repeat itself, but that historians do; admitting the latter part of the soft impeachment, it may be suggested that, notwithstanding obvious differences, there are some striking resemblances between the state of France to-day and that of the early fifteenth century. The Burgundians collaborated with a foreign invader, while the Orleanists had yielded with unseemly haste to the demands of the enemy. Later Bordeaux had persisted in its acquiescence to foreign rule; in France, the invasion of Britain was prepared, but failed owing to weather conditions and enemy action. Then the unfortunate peasantry, slaughtered and plundered by marauding bands claiming to be either Burgundians or Armagnacs, must have found it impossible to decide which side to support. And yet, into this welter of political complications, a young country girl, about 17 years of age, evolved a political faith, which to her contemporaries was miraculous and which the modern historian finds difficult to explain in simple terms; because at that time, national patriotism had not been formulated. *La Pucelle* was truly remarkable for the boldness of the plans she conceived, the energy and vigour with which she inspired their execution; as the Hungarian patriot, Kossuth, said, she must have been the youngest commander in the field that ever led soldiers to victory against troops, for she was barely 18 during her successful campaign of 1429. No pitched battles were fought, but the method of direct, rapid advance was practised, relieving sieges, taking towns by assault, capturing convoys; she achieved victory by her personal, courageous initiative in attack. All must pay homage to the bravery with which she endured her cruel imprisonment, numerous cross-examinations, repeated trials and subsequent flagitious execution at the stake.

As to the English, *les Coués*, except for Shakespeare and a few early authors who adhered to the wrong view that the trial was fair, they have been carried away with admiration for this romantic and singularly appealing historical figure. Then authors, who without being English, yet wrote in that tongue, like Francis C. Lowell, Andrew Lang, Bernard Shaw, noticeably fell under the magical influence of one who was executed as a sorceress, but whose spell has survived centuries and whose example still deserves the sincerest form of flattery. Even an irreverent professional jester like Mark Twain wrote with unfeigned admiration of the Maid from Domrémy.

It is sad to record that in modern times, the merits of *La Pucelle* have been subjected to party feeling in France so that a few years ago an *affiche* said, among other shameful misstatements: *Maladive, hystérique, ignorante, Jeanne d'Arc ne mérite pas nos sympathies* (quoted from Ouy-Vernazobres, 1929). There are moreover several booklets, in which, with the specious purpose of serving the cause of truth, it is denied that *La Pucelle* played any part in the shaping of the Kingdom of France; such would be: Lesigne, *La fin d'une légende* (1889), which asserts that the Maid was not really executed at Rouen; Paraf-Javal, *La légende détruite* (1929). Many panegyrics of the Saint have been published which explain the remarkable deeds of the Maid of Orleans as the outcome of Divine Inspiration and Aid; but even if we accept this interpretation, it will be conceded that the Supernatural Influence acted through the brain and consciousness of the girl, because the Voices and Visions were not physical, in the sense that they were

heard or seen by others besides herself ; and therefore they are a fit subject for psychological investigation.

Bernard Shaw stated in the truly remarkable Preface to his play, *St. Joan* : " Her ideal biographer must be free from nineteenth century prejudices and biases ; must understand the Middle Ages, the Roman Catholic Church and the Holy Roman Empire much more intimately than our Whig historians have ever understood them ; and must be capable of throwing off sex partialities and their romance and regarding women as the female of the human species, and not a different kind of animal with specific charms and specific imbecilities." It is quite possible to comply with these reasonable demands, except perhaps, those involved in the last 12 words. But even the full possession of this extensive knowledge would not help in solving the outstanding problem of Joan's personality, which can be thus bluntly stated : " If, as is so often asserted, she was a case of hystero-epilepsy, how came it about that she succeeded, where so many sane military commanders failed ?" A solution can only be obtained on the basis of a practical knowledge of psychiatry, combined with an understanding of the religious beliefs of the French countryside at the time, the fifteenth century. Such knowledge can be assumed in Norman, who in *Mental Disorders* (1928) wrote, p. 393 : " Joan of Arc had a chronic hallucinatory condition which is not regarded by many as being due to mental disorder, as it led to much bloodshed and served a useful purpose by assisting the French to beat the English. But she had to pay a fearful price for her affliction ". One cannot quarrel with this studiously fair opinion, which seems to be an echo of sentiments recorded during Joan's trial. It was then that the Minorite Friar, Jacques de Touraine, asked her whether she had ever seen Englishmen killed ; she answered : " *En nom Dieu, si j'y ai été?* Don't talk mealy-mouthed rot! Why do they not leave France and return to their country?" Whereupon an unnamed English lord exclaimed : " *Brave girl ! Would that she were English !* " Across five centuries this tribute of sincere admiration still deserves to be remembered.

Documentary and Legendary Evidence : Their Relative Value

Here an attempt will be made to sift documentary, historical recording from romantic or legendary tradition ; not that the latter is deemed worthless, far from it, but because it cannot throw any light on the question : " Were Joan's Visions the symptoms of mental disorder?' " My opinion is that they were not and that can be proved by a study of her deeds and ascertained answers in the course of prolonged cross-examination, which were carefully taken down by clerks in French and then translated into Franco-Latin, in which form they still exist. For this purpose the published documents have been consulted, in the first instance the five volumes due to the devoted scholarship of Jules Quicherat : *Procès de condamnation et réhabilitation de Jeanne d'Arc* (Paris 1841-9). Since the appearance of this monumental work, an important source of information relating to conditions in France during the lifetime of Jehanne has been printed : *Journal d'un bourgeois de Paris* (Paris, 1881), carefully edited by A. Tuetey ; the book is valuable, for it represents the Burgundian point of view. Gilles de Rais—by many thought to be the original of Perrault's Blue-beard—accompanied *La Pucelle* on some of her expeditions ; his life was described by E. Boissart and de Maule : *Gilles de Rais, maréchal de France, dit Barbe-Bleu* (1404-1440) (Paris, 1886). The letters of a Venetian in France have been discovered and edited by Leon Dorez and G. Léfèvre-Pontalis : *Chronique d'Antonio Morosini* (Paris, 1901). Similar letters were addressed to friends by a German merchant Eberhard von Windecke, and these were published by G. Léfèvre-Pontalis : *Les sources allemandes de l'histoire de Jeanne d'Arc* (Paris, 1903). The events recorded are mainly miraculous or were considered from that standpoint, but the letters give a clear view of the opinions of contemporary detached observers. G. de la Roche and G. Wissler edited : *Documents relatifs à Jeanne d'Arc* (Aarau, 1926). A comprehensive list of over 2,121 numbers was compiled by Lanéry d'Arc : *Le Livre d'or de Jeanne d'Arc—Bibliographie raisonnée, &c.* (Paris, 1894). Such are the works that can be usefully consulted to form an opinion as to the conditions under which our heroine was born, lived, died. The American historian, Francis C. Lowell wrote : *Joan of Arc* (Boston, 1896), a sound critical book in the best historical tradition. A general consideration of the life of *La Pucelle* was undertaken by Anatole France : *La vie de Jeanne d'Arc* (Paris, 1908) and though from such a mocking sceptic no reverence for sacred matters was to be expected, the treatment of the subject was careful, serious and fair, even if one disagrees with the suggestion made in the Preface, that the Maid was a dupe of monks and priests ; an

assumption for which no evidence can be found in the text. The book upset many admirers of *La Pucelle*, e.g. J. B. J. Ayroles: *La prétendue vie de Jeanne d'Arc, monument de cynisme sectaire* (1910). It also aroused the indignation of Andrew Lang, who proceeded to write—it is said in three months—*The Maid of France* (new edition, London, 1922). One must admire the generous spirit of the author, and a paragraph deserves to be quoted: "She was the consummation and ideal of two noble human efforts towards perfection. The peasant's daughter was the Flower of Chivalry, brave, gentle, merciful, courteous, kind, and loyal. Later poets and romance-writers delighted to draw the figure of the Lady Knight; but Spencer and Ariosto could not create, Shakespeare could not imagine, such a being as Jeanne d'Arc."

This poetically-worded tribute is not false or even exaggerated; and I may be allowed to recall the Saracen woman-warrior, Clorinda, in *Gerusalemme Liberata* of Torquato Tasso, because she was an instance of a widely-held opinion—also supported by James I of England—that the milk of the wet-nurse influenced the character of the child; Clorinda's ferocity in battle was due to her having been suckled by a tigress. Another reference of medical interest is that Clorinda's white skin was due to maternal impression, for her father and mother were Ethiopians. It may be that our increasing knowledge of hormones may yet prove that such ancient beliefs possessed some justification.

That great French soldier, Maréchal Foch, paid his tribute to her military strategy in the book *Jeanne d'Arc* (Paris, 1929); his opinion is especially notable for he had given historical examples, in the field, of the principle which Jeanne voiced: *En nom Dieu, attaquez!* Moreover at her trial she said that she told the soldiers to drive through the enemy and went ahead herself. Since her Visions were closely bound with political history, a review of the state of France at the time would be required, to obtain a proper perspective of her milieu, but owing to exigencies of space an account of the historical background must be omitted.

Jeanne d'Arc: Her Parentage and Early Childhood at Domrémy

The Maid of Orleans was born sometime between 1410-12 as the daughter of Jacquot d'Arc and his wife, Isabelle Romée; an exact date lacks documentary evidence. Jacquot and his wife were ordinary country people; their children were Jacques, Catherine, Jean, Jeannette and lastly Pierrelot. Though little is really known of the mentality of the parents, brothers and sister of the heroine, yet sufficient information is available to conclude that they were frugal, stolid, hard-working peasants, without a trace of neuropathic affliction. One may usefully compare their case history with those of the Kings, Charles VI, his son Charles VII, and grandson Louis XI.

There is some information regarding the early childhood of Jeannette through the repeated investigations by numerous persons during the first examination made on behalf of the King, then during the trial in 1431 and in the course of the rehabilitation which was proclaimed on June 16, 1456. Not unexpectedly, the aim of these informers was quite different from that of contemporary historians, with the result that many anecdotes recorded are of little documentary use, in showing that during her early childhood she behaved in any way differently from any other little girl of the neighbourhood. From her statements at the trial it is known that it was at the age of 13—presumably in the summer of 1424—that in her father's garden she first heard the "Voices", which frightened her, saying: *"Je viens de Dieu pour t'aider à te bien conduire, Jeannette, sois bonne et Dieu t'aidera."* A few days later the Voice said: *"Jeannette, sois bonne."* A third time she recognized the Voice as that of the Archangel Michael, who announced that St. Margaret and St. Catharine would soon visit her and advise her what to do.

For our purpose it would be most important to learn how soon the two Saints appeared after the first monitions, for they came in full daylight, so that their dress, speech and behaviour could be recognized. At first St. Catharine and St. Margaret gave commonplace pious advice on conduct, but one day they told her: *Fille de Dieu, il faut que tu quittes ton village et que tu ailles en France.* This was a political pronouncement, to which Jehanne's reply was: *Je suis une pauvre fille ne sachant ni chevaucher ni guerroyer.* At this time Jehanne's attendance to confession and church-going, fasting and praying became intensified and the voice of St. Michael told her that she should lead the Dauphin —that is, Charles VII—to Rheims so that he might be anointed King. Having decided to follow this advice, Jehanne did not consult her mother or father, but in 1428, visited a relative, whose wife was being confined; this Durand Lassois lived at Burey-en-Vaulx.

Joan persuaded him that she had a Divine mission to perform and he consented to accompany her to Vaucouleurs to interview the Captain of the town, Robert de Baudricourt, to whom she said that she had been sent by "*Messire*", i.e. the Almighty, so that he, Baudricourt, should tell the Dauphin not to engage in battle with his enemies. She added that before Mid-Lent *Messire* would aid the Dauphin, to whom the Kingdom of France did not belong, except in so far that the Dauphin should hold it in trust as King. "Notwithstanding his enemies, the Dauphin will become King and I, Jehanne, shall consecrate him". De Baudricourt was not impressed, but told Uncle Lassois to box her ears and take her back to her father. Jehanne returned to Domrémy after an absence of eight days and there was the object of derision and suspicion as a sorceress. In July Domrémy was ravaged by a force of Burgundians, so that the family of Jehanne fled to Neufchâteau, their market-place, and found hospitality with a woman named La Rousse, who kept an inn. Here Joan helped in the household work and took the cattle of her father out to graze; hence the English jibe "*vachère*", which she hotly resented; those cognizant with vulgar abuse will understand the offence intended, reinforced by the Instructing Judge d'Estivet, who later made out the inn of La Rousse to have been a house of ill-fame. In any case Joan was there no longer than a fortnight and then returned to Domrémy to find the village pillaged and its church in ruins. After a short time she again visited her uncle Lassois and went with him to Vaucouleurs, for another interview with Robert de Baudricourt, repeating her message, with the addition that she intended relieving the siege of Orleans. [Some authors cannot find evidence of two visits, but only one; the trend of the story makes two more probable.] This time de Baudricourt had her exorcised by his priest, Jean Fournier, who reported that she was a good Christian. Here she met a soldier, by name Jean de Metz, whom she convinced of the value of her mission and who agreed to accompany her to the King. It is Jean de Metz who apparently suggested that she should dress as a boy, a thing which later was followed by fatal consequences, though history records numerous authenticated instances of young women following armies in masculine apparel. On the 13th of February, 1429, Joan set out in boy's clothing from Vaucouleurs with Jean de Metz and Bertram de Poulengy and after eleven days' journey arrived at Chinon. Here she was interrogated by two prelates, Jean Girard and Pierre l'Hermite; this interview proving favourable she was taken into the presence of the King, who was surrounded by his Court. Jehanne was nowise abashed, doffed her cap and addressed him, saying: *Dieu vous donne bonne vie, gentil Dauphin.* It was considered a miracle that she recognized the King among the many courtiers present in the hall. The King asked her name and her request; she replied: *Gentil Dauphin, j'ai nom Jéhanne la Pucelle et vous mande le Roi des Cieux par moi, que vous serez sacré et couronné à Reims et serez lieutenant du Roi des Cieux, que est le Roi de France.* Charles then conversed briefly with her aside and then allowed her to retire; she was given a page-boy and lodged in the castle of Coudray. It was then that a prophecy of Merlin the Soothsayer was mentioned, which was understood to mean that a Maid would come from "*la ville du Bois Chenu*" who would accomplish great deeds. So far as it can be judged from existing documents this was a distorted version. At the same time, some alleged verses of the Venerable Bede were quoted: *bIs seX CVCVLLI, bIs septeM se soCIabVnt*=1429. These verses are not in the known writings of the Venerable Bede, but it was believed they were, which is quite enough for the purpose in view. Maître Jean Erault recalled a prophecy of Marie d'Avignon, dite la Gasque, who had told Charles V: *Une vierge viendra, et, par ses armes, délivrera le Royaume de France.* The King corresponded with Jacques Gelu and obtained his advice; he then deputed a panel of 15 theologians to question the Maid. Among the questions was that of Frère Guillaume Amery: *D'après vos dires, la Voix vous apprit que Dieu veut tirer le peuple de France de la calamité où il est. Mais si Dieu veut délivrer le peuple de France, il n'est pas nécessaire d'avoir des gens d'armes.* Her reply was energetic and to the point: *En nom Dieu! Les gens d'armes batailleront et Dieu donnera la victoire.* She then dictated a brief appeal to *Suffort, Clasdas et la Poule*, asking that they should return to England. (Earl of *Suffolk*; Sir William *Glasdale*; *de la Pole*, John or Alexander?)

At the end of six weeks the various theologians declared themselves satisfied. She was then seen, observed and examined by *mulieres doctas, peritas virgines, viduas et conjugatas si sit virgo.* These wise women were the Duchess of Anjou, Dame Jeanne de Preuilly, Jeanne de Mortemer, who at the age of 18 was the wife of Robert le Maçon, *homme d'un*

grand âge ; these ladies testified as to the purity of the Maid. At the same time messengers were sent to Domrémy and the conclusion of this was that Jehanne should be given a trial at the front ; accordingly she was allowed to accompany a military expedition to Orleans. This arrived at the outskirts of the city on Thursday, April 28, and next day they entered by the *Porte de Bourgogne,* which apparently was open ; it is recorded that Joan's plan was to attack the English and enter the town through them ; however, her guides took the line of less resistance.

Her Steadfast Purpose and Brave Deeds

From Orleans she dictated a letter which she sent by a herald named Guyenne, whom the English retained and threatened to execute. This she followed by another missive to Sir John Talbot, the Earl of Suffolk, and *Le seigneur de Scales* bidding them return to England. This message was not well received ; the answer being that they intended to burn Guyenne. The third time she dictated a letter to the English asking them to abandon the fortifications and to return to their country, offering to exchange her herald Guyenne against some English prisoners ; the message was attached to an arrow and shot over ; the answer was shouted back in offensive terms which made her weep.

On Friday, May 6, she rallied a failing attack on the Tower of the English ; next day she was wounded in the right shoulder by an arrow, which apparently passed through the muscles of the neck. She refused to employ a charm to stanch the blood and had the wound dressed with lard and olive oil and then, after having prayed, followed her standard, encouraged the attackers who were wavering, entered the trench and surmounted the palisades. On Sunday, May 8, the English, under Sir John Fastolf departed and the siege was raised.

The next care of the Maid was to persuade the King to accompany her to Rheims and there be consecrated ; it should be noted that the town and neighbourhood either favoured the Burgundians or were garrisoned by the English. Therefore to reach Rheims a military campaign was most brilliantly put into execution. On June 11 Jargeau was attacked and entered next day. Here it was that the Maid was knocked down and slightly stunned by a stone hitting her head ; but she soon got up and cried: *Amis, amis, sus, sus ! Messire a condamné les Anglais ; à cette heure ils sont nôtres. Ayez bon cœur !* The Earl of Suffolk was taken prisoner, together with his brother, John de la Pole ; another brother, Alexander, was drowned or killed. On July 15 the bridgehead of Meung was captured ; on the 16th Beaugency was invested ; it surrendered next day ; on the 18th, at Patay, an English train commanded by Talbot and Fastolf was broken up and captured ; then other towns, Troyes, Chalons, were invested and overcome ; at last Rheims was entered without opposition, so that the coronation took place on July 17, 1429, Jeanne being present with her banner, painted at Tours by a Scotsman, Hamish Power. In the meanwhile Joan was granted an allowance, was given an equerry to help her don her armour, which had been specially made ; she had a household, rode several horses presented to her ; all this is evidence of an intellect fully conscious of its power ; it was not exaggerated or vainglorious. The neglect of clothing or the donning of absurd apparel are well-known symptoms of a disordered mind.

In September 1429 she took part in an attack on Paris, in the course of which she was wounded in the thigh, but she remained on the field and spurred the soldiers on ; however, the assault failed. She returned early in November 1429, led the operations against Saint-Pierre-le-Moustier, where she is recorded to have cried: *Aux fagots et au claies, tout le monde ! Afin de faire un pont.* Here she was successful. There was another failure at La Charité and subsequent events are not quite clear ; it seems that Jeanne's restless activity began to be viewed with disfavour, her position and fame gave rise to envy and Court intrigues were evident ; the support of the King and his Counsellors, never whole-hearted, became even lukewarm ; the departure of Jeanne with a company of Italian mercenaries for Compiègne seems to have been her own initiative. It was there that she was captured by a captain of the Duke of Luxembourg on May 24, who sold her to the English on November 21, 1430 ; they took her to Rouen, where she was tried on a charge of sorcery and heresy before a tribunal consisting of theologians from the University of Paris. During her imprisonment she twice fell ill : the first time apparently through eating some fish sent her by Cauchon ; she was treated by bleeding by two physicians, Jean Tifaine and Guillaume De la Chambre. [These can be traced in Wickersheimer (1936), Jean Tifaine, *magister medicinae* of Paris, 1418 ; later a Canon of Rouen ; denied

at the Rehabilitation having condemned Joan ; died 1469. De la Chambre was Master of Medicine of Paris, 1436 ; at the Rehabilitation said that judgment had been forced from him.]

Between February 24-27 it was recorded that she was examined in relation to her virginity by the Duchess of Bedford, a Dame Ann Bavon and another unnamed matron. Here the purpose was evident ; it was held that a sorceress could not be a virgin. The result of the examination was in favour of Jeanne, but it can only be surmised how the matrons formed their opinion ; perhaps by questioning and an external examination. At that time, the existence and significance of the hymen was contested by medical authorities and some recommended strange methods of suffumigation with leaves of *Lapathum, ad probatio virginum.*

Jeanne's imprisonment was unnecessarily brutal, her trial and cross-examinations gruelling ; yet very rarely did her high courage fail her and none of her brief, firm answers show the least trace of that dissimulation which is common in paranoiacs when being questioned about their delusions. On the contrary, she gave a full account of the Voices she had heard, the Visions she had seen, and stated she had embraced the Saints. It is noticeable that she could not give a clear or definite description of the Saints and Archangels, except that she perceived them in the nature of a bright light, accompanied by the sound of a nicely modulated voice. Many of the leading questions may seem futile, but to those who are acquainted with Demonology it is evident what the theologians were attempting to prove ; they failed in this, though Paris University decided that the Visions of Jeanne were due to three Devils, Belial, Satan and Behemoth. The other conclusions were of the same nature and moreover they brushed aside the plea of Jeanne that she might be allowed to appeal to the Pope. As it happened, after a period in which three Popes had claimed the See of St. Peter, during her trial it was vacant, though the news had not reached the Tribunal. Anyone reading the answers of the Maid to the questions of her judges, will agree that they are direct and to the point, with none of those irrelevant tirades which are voiced by hysterical subjects. At no time, under the most difficult circumstance, did Jeanne faint, react with fits of any nature or behave otherwise than with brave confidence. There was, it is true, a recantation followed by a relapse, the doffing and donning again of male clothing, but those who have followed the recent political trials of Russia may draw their own conclusions as to how steadfast Jeanne was in the face of overwhelming intellectual pressure. Her behaviour throughout was that of a singularly brave, intensely devout, self-assertive, young country girl.

She was burnt at the stake in the Market-place at Rouen on May 30, 1431, in the presence of soldiers and the populace.

The Voices and Visions of Jehanne La Pucelle

In attempting a revision of the medical aspects of the story of Joan of Arc, it is taken for granted that in the last forty years medicine has made considerable advances in the diagnosis, prognosis and even what is called the "causation" of many morbid mental conditions. In medical matters, the word "cause" has obtained a limited, definite meaning ; it really amounts to answering the question : How ? And not the other profound query : Why ? Thus there is some justification for re-examining what the Maid said and did, without probing much deeper, in a vain struggle to find out the Original Cause of her actions, even by the methods of Metaphysics.

The report by Dr. Georges Dumas (1908) is the latest authoritative study of the subject ; he concluded that in her behaviour Jeanne was sane ; this view can now be reconsidered in the light of contemporary knowledge of medical psychology and psychiatry.

It has been mentioned that the "Voices" and "Visions" of the Maid are accepted by devout Roman Catholics as being of Divine origin, while sceptics with or without psychiatrical pretensions, consider them illusions, hallucinations and delusions, the symptoms of a diseased imagination. I am not qualified to accept or oppose the former standpoint, but I intend to bring evidence to prove that *La Pucelle* behaved as a sane person would in her time and circumstances, provided he held the same innate opinions she had tried to put into practice ; moreover that her visions were not morbid.

On the basis of a careful study of the life and surroundings of Jeanne, it becomes evident that in her time it was quite possible to be abnormal, without deserving to be classed as insane. In this sense, in 1492, the opinions of Columbus were abnormal, they may even have been considered diseased, but events did not prove him disordered in

intellect. Though the Visions of *La Pucelle* were the feature which has obtained the most attention—undeniably her behaviour seemed to be guided by these Visions—yet I have concluded that it is her deeds and conduct that really count in forming a judgment; momentary reflection will recall that diagnosis in psychiatry is more often based on behaviour than on the expression of unorthodox opinions.

An attentive study of the reported sayings of Jeanne and of her answers under cross-examination, shows quite conclusively that she firmly believed that she had a Divine Mission to accomplish—the crowning of the King of France at Rheims—and consequently to lead troops to chase the English from France—*bouter les Godons de France.* Other plans were adumbrated, reconciliation with the Burgundians, a common Crusade against the Infidels, but there was no opportunity to carry them out. According to her view, she had been chosen for this mission by Saints and Archangels, who appeared to her in Visions and told her what to do.

What I have attempted to show was that the Voices of Jeanne, if one does not wish to accept their miraculous or Divine origin—or for the matter of that, even if one does—began as simple, moral admonitions at the age of 13. Anyone who has experience with children must know that innocent illusions are frequent, some as recurring dreams, which easily take on a fanciful interpretation of actual events.

In the case of Jeanne, later on—it is not clear when, possibly after two, three or four years—the appearances of Saint Margaret and Catharine and the Archangel Michael, resulted in advice which was political in character. Here was something more abnormal, but it seems evident to anyone who reads her recorded replies that there was an additional factor, that of auto-suggestion; she saw things she wished to see and the Voices bid her do things she wished to do. It is true, according to her confession, that twice she neglected the advice of her Counsellors; once when she jumped out of prison, the other time when she cast off masculine clothing; both instances occurred during her imprisonment.

All those who have studied her story and tried to obtain an explanation in the realm of psycho-pathology, have found it difficult to reconcile what seemed to be a system of delusions, together with actual, definite practical achievements, accompanied by a perfectly normal behaviour in all matters pertaining to ordinary circumstances of life.

Joan of Arc has been frequently mentioned together with another remarkable young woman, St. Catherine of Siena (1347-80), but anyone with sufficient clinical knowledge will admit that it is a question of contrast, not comparison. The achievements of St. Catherine were great, her letters remain as the proof of an ardent spirit furthering the return of the Pope to Rome, by means of astoundingly gentle, and yet irresistible, pressure. Apart from this, St. Catherine was an ascetic, a young woman with a frail body, who ill-treated herself in a manner which arouses horror in the modern reader of her life.

The life of Florence Nightingale (1820-1910) can be recalled as a modern example of an inspired action by a woman in the face of great difficulties and opposition. The Lady of the Lamp was as convinced of the vital importance of her mission of reform as was Jeanne, but she did not find it necessary to enforce her views by describing visions or messages from St. Catharine, St. Margaret and the Archangel Michael; she could rely on her relatives in Government circles.

The peasant girl from Domrémy was built of stern stuff and, apart from her Visions, in her behaviour was a true sturdy daughter of the soil. Accordingly her performances both in the field and in the realm of practical politics, involved much more genius in action.

The Causation of the "Voices"

As to the *fons et origo* of the Voices, illusions are not uncommon in young people of both sexes about the age of puberty; to such, Jeanne added others which were the outcome of her intensely religious feeling together with what I do not hesitate in calling the inspiration of genius, in relation to French patriotism. I am fully aware that I shall be confronted with the view originally expressed by Seneca and then poetically voiced by Dryden:

> *Great wits are sure to madness near allied*
> *And thin partitions do their bounds divide.* [*Abs. and Ach., line 163.*]

This is an opinion with which I cannot agree, but the reasons cannot be discussed now.

If I were asked to give in clear, simple language, the essential difference between genius and insanity, I would say that outstanding talent is creative, constructive, and productive;

whilst insanity is either destructive or disordered, and incapable of obtaining lasting results. There have been instances of mental disease complicating outstanding ability, e.g. William Blake, but they are not many. What popular authors such as Nisbet confuse with insanity are the eccentricities of brilliant men, quite another matter.

There is a matter of medical interest which can be examined in the light of modern endocrinology. It can be accepted, from the testimony of Jeanne's squire, d'Aulon, that she was amenorrhœic, though her figure was well developed. There has been a natural reticence in discussing such matters among non-medical authors, but clinical experience tells us that scanty catamenia are the rule in exceptionally active women ; this is already mentioned in Soranus ; it may be said that they are intellectually and physically active because of slight interference from the genital sphere or the other way round ; but however the explanation is worded, the observation is correct. It is now admitted that menstruation is influenced by the secretion of definite hormones, the chemical constitution of which has been analysed. What is ascertained is but a minimal fraction of what is still unknown, but it is clear that such hormones, apart from a uterine, possess a cerebral action, so that disturbance in their secretion must result in a repercussion in the mentality. Accordingly, Jeanne's vigorous personality can be more easily understood. We do not know what her inner thoughts may have been, but it has seemed to me that her insistence on dressing as a young man may have been in part suggested by the fact that she would feel that " she was not like other girls ", a phrase well known to every medical practitioner.

Jeanne's physical vigour is confirmed by several contemporary independent reports ; she would walk or ride long marches, not only on the scantiest fare, but, moreover, was punctilious in observing all fasts decreed by the Church ; she kept fully armed and dressed six days on end, sleeping on straw in barns ; she was seriously wounded at Orleans and rejoined the fray, after a brief period of rest and prayer. It has been calculated that between February 15, 1429, and May 23, 1430, she travelled on foot or horseback 5,329 km., that is 3,330 miles in fifteen months. Her behaviour during imprisonment and trial can be once more admiringly mentioned. Against this it can be said that she was easily moved to tears by insults or disappointment ; that at Jargeau she jumped from her horse to tend an English prisoner, who had been cruelly struck by his French captor. This facile womanly emotion seems to me an added evidence of sanity ; all those who have experience of the insane know how little they are moved by exterior circumstances. It has been poetically said that it is a poor world, where there is dearth of woman's tears ; but apart from this I have seen a Nursing Sister weep out of bitter disappointment when one of her favourite wounded was moved to another ward, for she mollicoddled him ; yet this brave woman, alone, one early morning in the Transvaal, had shot five lions.

Some authors, like Andrew Lang, have discussed the prophetic savings of Jeanne, to show her prescience ; I do not think that they are psychologically important. Her prophecies seem to me to have been in the nature of encouraging assertions, which in medical practice are known as " favourable prognosis "; our credentials in such instances being past and present experience.

It is important to note that though *La Pucelle* claimed Divine Inspiration, she repeatedly disclaimed the possession of miraculous powers in relation to healing ; there is an instance where she revived an asphyctic newborn babe, which died, however, soon after she had baptized it ; from this and her acting as godmother to several infants, one can decide that, notwithstanding her soldierly activities, she still remained a womanly woman.

Shakespeare and the Maid of Orleans

Anyone acquainted with the story of *La Pucelle* recorded in numerous documents, cannot fail to notice that her dramatic representation in the Shakespearean play, " Henry VI ", is a strange travesty, at least in parts. At first the Maid claims to be the bearer of a divine mission ; her military leadership is admitted, for she takes part, a leading part, in a stratagem to capture Rouen ; she overcomes Talbot in single combat, an incident for which there is no historical evidence ; her vigorous patriotism is evident, for she is ready to shed blood, risk life and limb for her country. But later on, her Voices are " fiends " and remain dumb when asked for advice ; she then refuses to recognize her father and claims to be nobly born ; after condemnation she presents a plea for delay of execution, because she is with child, the father named being first d'Alençon and then Rayner of Naples.

We have learnt from a youthful literary critic that modern research has shown that the plays were not written by William Shakespeare, but by another gentleman of the same name ; and thus it would be perhaps unfair to saddle the Great Bard with this fanciful presentment of a noble historical character; indeed, it has been suggested that collaboration might explain the contradictory and inaccurate account of the story of the Maid. Later English authors have given a better account of the life of St. Joan, particularly Bernard Shaw, who, having said that she was mentally excessive, to prove his contention, makes St. Joan talk like Beatrice Potter (Mrs. Sidney Webb).

Voltaire wrote a scurrilous and ribald poem about *La Pucelle ;* he had just sufficient decency to disclaim its authorship ; it is no excuse to say that he was attacking Clericalism ; he obviously did not take the trouble to get his main facts right, for Joan was a victim of Sacerdotalism, if ever there was one.

Christine de Pisan (*c.* 1364 - *c.* 1430) the Poetess of "l'Amour Courtois"

During Joan's lifetime, a poem in her praise was composed by Christine de Pisan, a most engaging and interesting personality. She was the daughter of an Italian astrologer and physician, adviser to Charles V of France. Brought up in Court circles, she married a notary at the age of fifteen, who died when she was 25, leaving her with three children. She courageously set about earning her living by writing ballads in that peculiar style known as "*l'amour courtois*", which was the forerunner of the strange aberration known as "*cicisbeisme*". She also wrote didactic works and "*La cité des Dames*" as a defence of her sex. Eventually retiring to a Dominican nunnery at Poissy, she ceased writing, but when the fame of Jeanne's deeds reached her she composed a poem beginning:

Je, Christine que ay pleuré XI ans en l'Abbaye close . . .

in which she greatly rejoiced at the victories won by one of her sex ; the events were due to Divine guidance and her feelings were expressed with the verses:—

Si rabaissez, Anglois, vos cornes, Car jamais n'avez beau gibier.
En France, ne menez vos sornes, Matez estes en l'eschiquier.

Freely translated : "Lower your pride, Englishmen, for there is no more good game for you in France. It is no longer fun, you are checkmated on the board."

A full study of the literary significance of Christine is by Marie-Joseph Pinet : *Christine de Pisan,* &c. (Paris, 1927).

For our purpose the character of two remarkable women can be compared, whose upbringing and activities were so different and yet had similar aims in view : the furtherance of French dynastic patriotism.

Christine was well read and dynastic loyalty was easily understandable in her ; it was in her interest to sing the praises of the *sang royal.* She had definite ideas about State policy and these she expressed in many writings in the words : "Let the King rule wisely and well." Jeanne was a peasant girl, could not read or write and she summed up her views on statesmanship : "Let the French King reign under the guidance of God." Both Christine and Jeanne were devout Christians, but it is evident that the reading of pagan authors and the glamour of Court life had made religion for Christine rather a formal matter ; she lacked the fervour of Jeanne ; moreover, she was a wife, a mother and was, rightly, greatly concerned with protecting her progeny. These considerations did not arise with Joan, who brushed aside all conventions to carry through with the impetuosity of genius, what in modern terms would be called a three-point programme : Crown the Dauphin in Rheims ; chase *les Godons* from France ; make peace with the Burgundians.

The Iconography of Jeanne d'Arc

A few words may be added about her pictorial representation ; a strange head of a helmeted woman has been suggested to be Joan ; this has been hotly contested ; instead, it has been stated, it is a St. George or St. Maurice. To my mind it represents very clearly the face of a sturdy country girl such as may be seen any day in the fields of the Lorraine. Moreover, Paul: *Posséderions-nous le vrai visage de Jehanne d'Arc?* Aesculape, 1939, **29**, 74-77, has compared the profile of one of the male descendants of her family with that of the statue and found them to resemble strongly ; this is but to be expected in view of what has been said. During her life there is no record of a real picture of Joan ; those existing in miniatures are, as a rule, puerile. It seems that her hair was black, for she used a hair to seal one of her dictated letters.

THE ESSENCE OF THE PSYCHOLOGICAL DIAGNOSIS OF JOAN OF ARC

A benevolent critic, having read my essay, told me that three main conclusions I had obtained, were already much more entertainingly presented by Bernard Shaw in the Preface of his *St. Joan*: that the Voices of St. Joan were simply the inspiration of genius; for Shaw said that Newton had not found it necessary to clothe his discoveries in the form that the ghost of Pythagoras had walked into his garden to tell him that the apple had dropped on his head as the result of gravity; that Joan was one of the first apostles of Nationalism and the first French practitioner of Napoleonic realism in warfare, as distinct from the irregular scrapping hitherto practised; and that Shaw had recognized St. Joan as being mentally excessive, not mentally deficient. What could I do, but haltingly concede that it was most flattering to find myself in agreement with one of the foremost minds of our time? Nevertheless, in walking home, SS. Cosmas and Damian whispered into my ear—or it may have been the spirit of Sir Patrick Manson—that many had asserted that malaria was connected with marshes, but proof of the mosquito cycle was required for the purposes of medical progress. By the same token, though Shaw had made a dogmatic assertion, I had tried to show how such a conclusion could be reasonably obtained, for all to contest or approve. Incidentally, in the same Preface it was stated that St. Joan was the first Protestant martyr. Now, the irreducible nucleus of protestantism is that it will not recognize the supremacy of the Pope; instead, Jeanne was only too willing to admit it, except that during her lifetime it was not easy to decide. In 1410 John XXIII had been deposed, being followed by Martin V in 1417, while others had claimed the right to occupy the See of St. Peter. In 1429 the Anti-Pope Clement VIII had resigned; so that at the time of trial there was no Pope, till Eugenius IV was elected in 1431. It is known that Jeanne had been asked to express an opinion on the claims of the rival Popes and had given an evasive reply; a further sign of sanity, for it is only the half-witted who are cock-sure. She was, in fact, a better Papist than her judges, some of whom later took part in the Synagogue of Satan, the Council of Basel.

There are numerous other subjects, some connected with medicine in its wider aspects, where disagreement with Bernard Shaw could be substantiated; but as the result of a study of reliable documentary evidence, it can be suggested that the behaviour of Jeanne d'Arc was perfectly sane and that the formulation of her constructive ideas bore the impress of genius. This country girl was truly the Flower of Chivalry.

My reading of the story of Jeanne d'Arc is, therefore, that her Voices and Visions were largely the product of auto-suggestion based on intense religious beliefs and were nowise accompanied by any recognizable form of mental derangement. Soon, the inner conviction was obtained that a remedy for the pitiful condition of the Kingdom of France could be achieved by consecrating Charles VII in Rheims, obtaining the reconciliation of the warring factions, and driving the invader from French soil. To put this into practice, active participation in the war was decided and its actual performance was accomplished in a manner and by the means perfectly suited to the spirit of the time and country. In modern times others might profit from her example.

JOINT DISCUSSION No. 2

Sections of Surgery and Pathology

Chairman—J. B. HUNTER, M.C., M.Ch.

(President of the Section of Surgery)

[*January* 6, 1941]

DISCUSSION ON THE PROBLEM OF BLAST INJURIES

Professor S. Zuckerman, Department of Human Anatomy, Oxford. (*Work carried out for Research and Experiments Department, Ministry of Home Security*): Aerial attacks on civilian populations raise problems, both in the field of passive defence and in that of medicine, that are new in warfare. They are new not because of any novel quality of bombs or high explosive, but because circumstances make them new. More tons of bombs are dropped on this country almost every night than were dropped in the whole of the 1914-1918 war. They are dropped not in any one place, but far and wide. To-day everybody is exposed not only to the health risks of peacetime, in many cases intensified by changed living conditions, but also to the casualty hazards of air raids. Neither partial and isolated observations, nor preconceived conceptions of what happens in warfare, can show what these hazards are. The medical problems so acutely raised by air raids form a new sphere of research which demands in its attack more than simple clinical observation in hospitals. It was in the realization of this fact that the Research and Experiments Department of the Ministry of Home Security initiated, as part of its programme, a two-sided investigation of the physiological effects of high explosive and of the actual circumstances under which different types of casualties occur.

A bomb is a charge of high explosive encased in metal. Its primary effects (as distinct from any secondary effects due to secondary missiles and falling debris) are clearly defined. In a remote possibility a man may be directly hit by the bomb itself; more frequently he will receive wounds from splinters of the metal casing, or be affected by the blast wave set up by the explosion; in certain special circumstances he may be burnt by the flame of the explosion or poisoned by the gases it generates. However remote they may be from the accidents of civil life, and even though each of them to-day presents special problems for investigation, splinter wounds, burns and carbon monoxide poisoning can be fairly readily understood on the basis of existing knowledge. The effects of blast, however, do not come into any experience of civil life—except when a disaster occurs in an explosives factory.

To a Medical Officer of the 1914-1918 World War, blast was something that blew a man to pieces, or threw him violently. The clinical literature of that period contains practically no reference to the possibility that blast, other than injuring the ear-drums, can directly cause injuries in the thorax and abdomen without surface wounds. The Spanish war gave a different meaning to the term, for numerous observers reported that the blast from bomb explosions could kill at long distances, even when the casualty had not been struck by splinters or secondary missiles. People so killed were picked up dead in the area of an explosion, without any external injury and usually showing blood-stained froth in the mouth and nose. It is realized to-day that these reports exaggerated the

danger of blast and the distances at which it can cause casualties ; but recent experiences in this country have confirmed the fact that blast can hurt without either blowing a man to pieces or just throwing him to the ground.

Stories of men dead in battle without external injury were also current in the 1914-1918 war. Mott (1919), for example, describes a few such cases in some of whom nervous lesions were found. In general, however, as is clearly indicated in the Report of the War Office Committee of Enquiry into " Shell-shock " (1922), there is little or no evidence about the cause of death in any of these cases, either from the point of view of the circumstances in which it occurred or from that of post-mortem examination. Reconsideration of observations made in 1914-1918 suggests, however, that lung injuries unassociated with open chest wounds did occur during the First World War. Thus Thompson (1940), in a discussion of 250 cases of penetrating chest wounds includes " 24 cases of non-penetrating wounds or cases in which penetration was doubtful, because in all such cases injury involved either the lungs or pleura as shown by hæmoptysis, pleurisy or pulmonary collapse ". Lockwood (1940), again, writes of men who died as a result of a near-by shell or bomb explosion, without apparent wounds, or from a wound so slight or in such a position that it could not in itself have been the cause of death. According to him, such men manifested " rupture of the visceral pleura of the lungs or a complete collapse of the lungs, through the suction of air incidental to the blast, or due to reflex or bends ".

Experimental

Some experimental observations on the effects of blast were also available at the start of the present war. In 1918 Marinesco reported the results of experiments in which dogs were exposed to the blast of small charges of " fulmicoton ". Blood was observed in the nose and mouth of one animal, and others exposed in " shelters " suffered afterwards from dyspnœa, depression, and difficulty in walking. Microscopic, and occasionally larger, hæmorrhages were observed in various parts of the central nervous system, and more obvious hæmorrhages in the lungs. Hæmorrhagic lesions occurred less frequently in the liver, spleen, kidney, and adrenal. Similar pulmonary and nervous lesions were observed by Mairet and Durante (1917, 1919), while Hooker (1924), in the course of an experimental study of the shock produced by charges of T.N.T. and gun-blast, found that bruising and occasionally rupture of the lungs was " the single gross lesion found post-mortem in cats, dogs, and rabbits after exposure to air concussion due to gun-blast or high explosive ". Hooker also found that disturbances of respiration were frequent and set in at variable times after the explosion. Some animals died as a result of being exposed ; others recovered immediately ; while rabbits and cats died when exposed to blast which failed to affect dogs seriously. More recently, in physiological studies carried out in this country under the supervision of Sir Joseph Barcroft, F.R.S., in connection with official tests of sectional steel shelters, similar lesions were observed in the lungs of goats and rabbits exposed to the blast of a 500 lb. medium case bomb. (Sectional Steel Shelters: Report upon Investigations of the Standard of Protection Afforded. H.M. Stationery Office, 1939.)

Our first experiments were designed to discover how blast produces lesions in the lungs and in other organs.[1] In the course of this study, in which numerous animals have been exposed in successive experiments to the blast from surface charges of H.E., observations relating to lesions in other organs of the body have also been made. The charge of H.E. used in our studies varied in different experiments, the maximum being 70 lb. ; in all cases the explosive was detonated in paper containers so as to avoid any effects of flying missiles.

The Nature of Blast

When a bomb detonates, the solid explosive is converted into gases which initially are confined in the casing at a pressure that has been variously estimated as between 100 and 650 tons per sq. in. As a result of this pressure, the casing is blown to pieces, and the gases escape, and by their expansion produce a blast wave in the surrounding air. The blast wave is a single pulse of increased pressure followed by a phase of suction, and

[1] Detailed reports of these studies will be published later. Dr. P. L. Krohn, Dr. R. B. Fisher, Dr. D. Whitteridge, Dr. E. H. Leach, Dr. F. H. Kemp, Dr. C. W. M. Whitty, Dr. D. L. M. Doran and Dr. T. McKeown have collaborated in different parts of the research.

in general form is similar to a single pulse of a large amplitude sound wave (fig. 1). The wave moves extremely rapidly, much more rapidly than sound close to the explosion, and, in the case of a medium-sized bomb, falling to the velocity of sound (1,120 ft. per sec.) at about 200 ft. The total duration of the whole wave at any given point within 200 ft. of an explosion is very brief. Thus at 30 ft. from a 70 lb. charge the pressure component lasts about 5 and the suction component 30 millisecs. The duration of the pressure

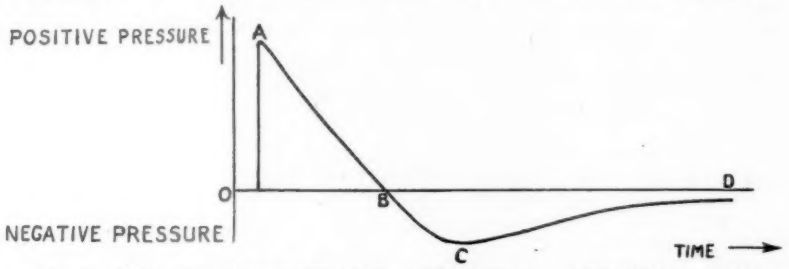

FIG. 1.—Diagrammatic representation of shock-wave. Adapted from A.R.P. Handbook No. 5, "Structural Defence". Reproduced by permission of the Controller of H.M. Stationery Office.

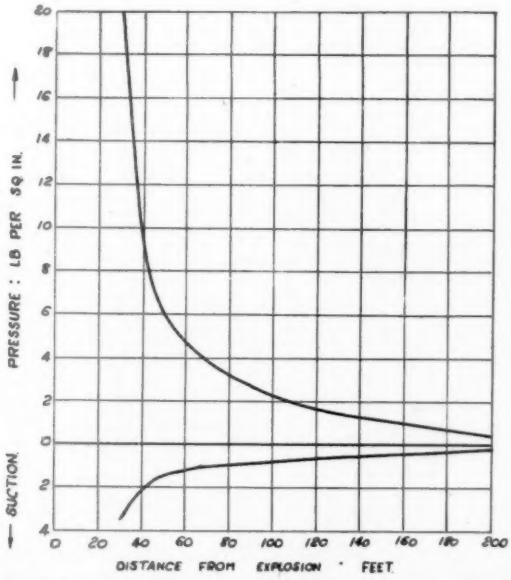

FIG. 2.—Maximum blast pressures and suctions from medium case bombs. From A.R.P. Handbook No. 5. Reproduced by permission of the Controller of H.M. Stationery Office.

component increases progressively with increasing distance from the charge, but the suction component, which generally lasts three to five times as long, remains more or less constant. It should be noted that the velocity and duration of the pressure wave at any given point are such that a body as large as a human being would certainly be completely immersed for an instant in a wave of almost uniformly raised pressure.

The maximum pressure of the wave is highest in the region of the explosion, and the

pressure at first falls rapidly the further the wave moves from the source of the explosion (fig. 2). In the case of a 70 lb. charge the pressure falls approximately as follows :—

14 ft. 110 lb. ; 18ft. 60 lb. ; 30 ft. 15 lb. ; 50 ft. 6 lb.

These figures represent hydrostatic pressure in excess of normal atmospheric pressure, which is approximately 15 lb. per sq. in.

Any surface facing an explosion will be subjected not only to this excess hydrostatic pressure but also to pressure due to air-movement immediately behind the shock-front of the blast wave. Close to an explosion this pressure may be as great as, or greater than, the hydrostatic pressure of the shock-front, but further from the bomb the pressure effect of this air-movement is of little importance ; it is negligible for hydrostatic pressures less than 5 lb. per sq. in.

The suction component of the blast wave is always much weaker than the pressure component, and in no case can it ever be greater than 15 lb. per sq. in., since this corresponds to a perfect vacuum.

The magnitudes of the pressure and suction components of a blast wave and the time they last are directly correlated with the amount of explosive, and are much higher for larger than for smaller amounts. On the other hand, if a given positive pressure is caused by a given amount of explosive at a given distance, the same pressure will be experienced at twice that distance only when the amount of explosive is increased eight times.

All things in the immediate neighbourhood of an explosion thus first experience a violent increased pressure, which may tear them to pieces and blow them far from the scene of the explosion, or affect them directly without doing either of these things. Whether or not an object is shattered by, and blown in the direction of the pressure wave, it may later be pulled towards the centre of the explosion by the backward movement of air associated with the weaker suction wave, because of the longer time for which this acts.

It should be noted that close to the point of an explosion the advancing wave's front is uneven, so that objects at equally close distances to the point of detonation may be exposed to different pressures. Further away from the explosion the blast wave becomes more even.

Direct Effects of Blast on Animals

The effects of blast have been studied in mice, rats, guinea-pigs, rabbits, cats, monkeys and pigeons. In general it has been found that different species vary in susceptibility, and that animals exposed close to an explosion (i.e. exposed to a higher blast pressure) suffer more than those further away. No lesions have been observed at pressures of 5 lb. per sq. in., while small mammals such as rabbits may be killed instantaneously at pressures of 50 lb., and are certainly killed at pressures approaching 100 lb. per sq. in.

Field observations.—Animals immediately adjacent to an explosion are blown to pieces. Further away there is a range of pressure, which varies from species to species, in which all animals will be immediately killed, without external injury, but often showing blood-stained froth, or blood, in the nose, mouth, and upper respiratory passages. Still further away, and with considerable variation for different individuals, is a zone of pressure in which animals are found alive immediately after an explosion, but die at intervals varying between a minute and a day. Animals in this group may have blood-stained froth in the upper respiratory passages and often suffer from air-hunger, dyspnœa and tachypnœa. They are usually apathetic and quiet, and disinclined to feed. Such animals are nevertheless capable of considerable physical exertion. Knee-jerks, corneal and pupillary reflexes have been found to be normal immediately after the explosion. Even hearing does not seem (on superficial examination) to be impaired. Observations on immediate changes in blood-pressure are now in progress. Observations on blood-counts, coagulation-time, and cell fragility have not yielded positive results.

Some animals which show blood in the upper respiratory passages, and which exhibit most of the characteristics that have been mentioned, survive the twenty-four-hour period, and recover completely.

Still further from the explosion, in a zone of lower pressure, animals are unaffected externally by the explosion, although internal examination reveals changes in thoracic, and occasionally abdominal, organs. Animals exposed beyond this zone of pressure exhibit neither external nor internal effects of the explosion.

Post-mortem appearances: (1) *The lungs.*—The most outstanding lesion, as was found by Marinesco and by Hooker, is hæmorrhage in the lungs, varying in degree according to the pressures to which the animals have been exposed. The following description has already been given of the pulmonary lesions (Zuckerman, 1940):—

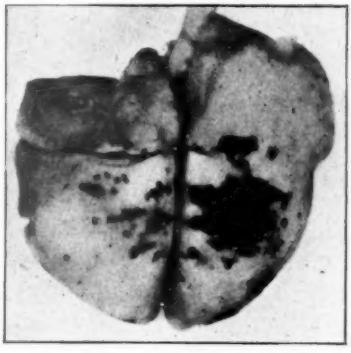

FIG. 3.—Lungs of a rabbit exposed to blast, showing small areas of hæmorrhage, following the lines of the ribs.

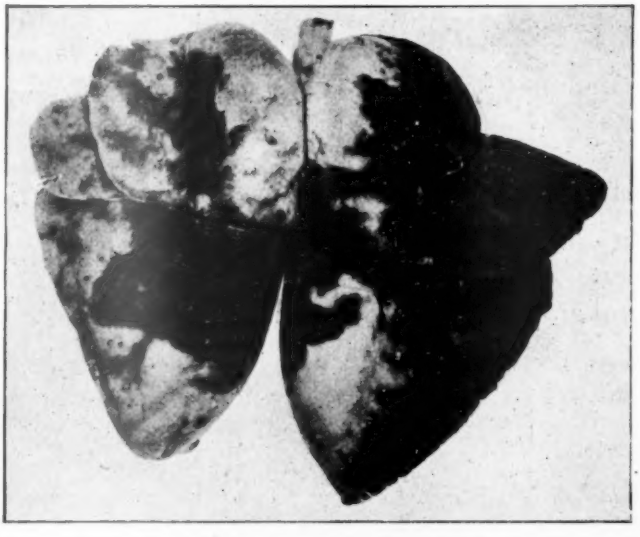

FIG. 4.—Lungs of a monkey exposed to blast, showing more extensive areas of hæmorrhage.

"To direct inspection the lesions, in cases of very slight damage, appear as spots of hæmorrhage on the surface of the lungs (fig. 3). In severer cases, patches of hæmorrhage, of varying size, are present (fig. 4), and in very severe cases the entire surface of the lungs is hæmorrhagic (fig. 5). The hæmorrhages often follow the line of the ribs

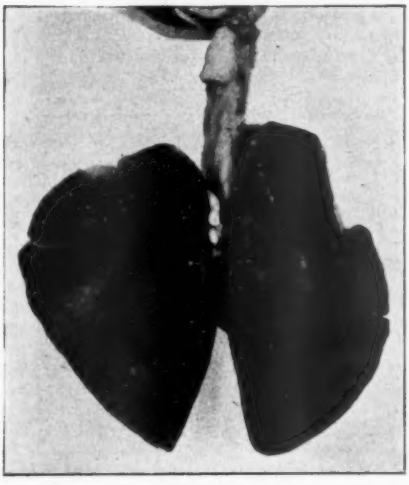

FIG. 5.—Very severe hæmorrhages throughout the lungs of a rabbit exposed to blast.

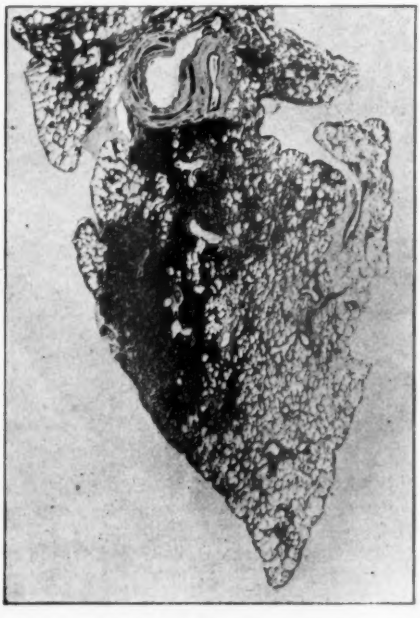

FIG. 6.—Section through lung of a cat exposed to blast, showing extent of a zone of hæmorrhage.

(fig. 3), and even when the hæmorrhage in the lungs is sufficiently extensive to affect almost the entire surface, darker lines of hæmorrhage following the lines of the ribs can sometimes be recognized against a background of lighter hæmorrhage. In most severe cases there may be superficial laceration along the lines of the ribs, which have presumably been driven into the lungs (*see below*). In such cases a hæmothorax and pneumothorax occur.

" When the lungs are sectioned, confluent zones of hæmorrhage, in very severe cases, are seen to extend almost through their entire substance (fig. 6). In some very severe cases the lungs were completely ' hepatized ' by hæmorrhage. In less severe cases localized and scattered hæmorrhages occur, sometimes in relation to a large bronchial tube. In slight cases points of hæmorrhage are present and are mainly subpleural in their disposition. As a general rule areas of internal hæmorrhage are related to zones of hæmorrhage visible on the surface.

" The most vulnerable regions of the lungs are the anterior borders, which become pressed (*see below*) between the front of the chest wall and the mediastinum, and the inferior borders, which become compressed in the costophrenic sinus. The costal surfaces are also a site of election, and another very common site of injury is the mediastinal surface of the lungs, and in particular the azygos lobe, which passes from the root of the right lung across the mid-line behind the heart towards the left side.

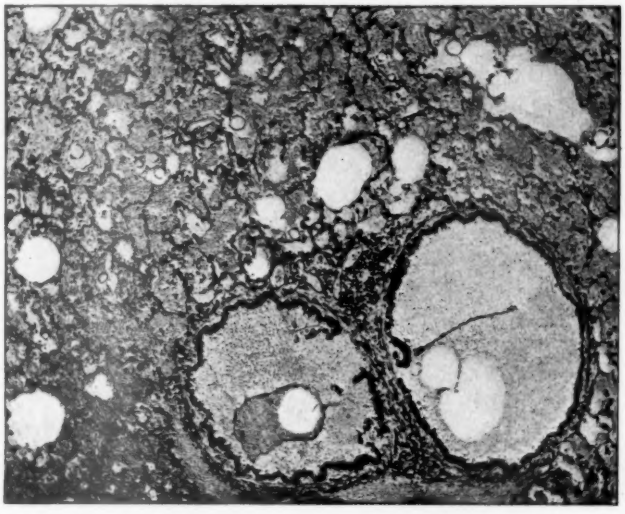

FIG. 7.—Section of a rabbit lung after exposure to blast. The alveoli and bronchioles are filled with blood. × 71.

" In all cases where the degree of lung injury has been sufficient to kill the animal, blood was found in the bronchial tubes, the trachea, and usually the mouth and nose. Blood is not found in the trachea or nasopharynx of animals which have been only moderately injured by blast, and it is occasionally absent when there has been extensive damage."

The following observations can be added to this description. Lacerations occasionally occur on the borders of the lungs, which may show a disproportionate amount of internal as compared with external hæmorrhage which, however, is always present ; lesions often appear more pronounced on macroscopic examination in animals that die some hours after an explosion than in animals killed by the explosion ; and finally no lungs, in a series of several hundred, have been observed in which the lesions took the form of small uniformly-scattered foci of hæmorrhage.

Microscopically the areas of damage appear as zones in which the alveoli and the smallest bronchial tubes are filled with blood (fig. 7). The alveolar walls can often be seen to be disrupted, hæmorrhage originating in the torn alveolar capillaries. Interstitial hæmorrhage also occurs. In severe grades of damage large areas of the lung are disrupted and hæmorrhagic, and the larger bronchial tubes become filled with blood. Collapse unassociated with hæmorrhage has not been observed except during the process of healing.

Observations on cats show that all but the lesser degrees of lung bruising are detectable radiologically, the lesions appearing as areas of mottling and shadow.

It is difficult to make any definite statement about the rate of healing of the lesions, owing to the impossibility of determining the initial amount of damage in a given lung. X-rays of cats that had been exposed to blast suggest that the process is rapid, but mice and rabbits examined up to forty-five days after exposure have still shown superficial, though not deep, signs of previous damage. Pleural adhesions are not uncommon, and

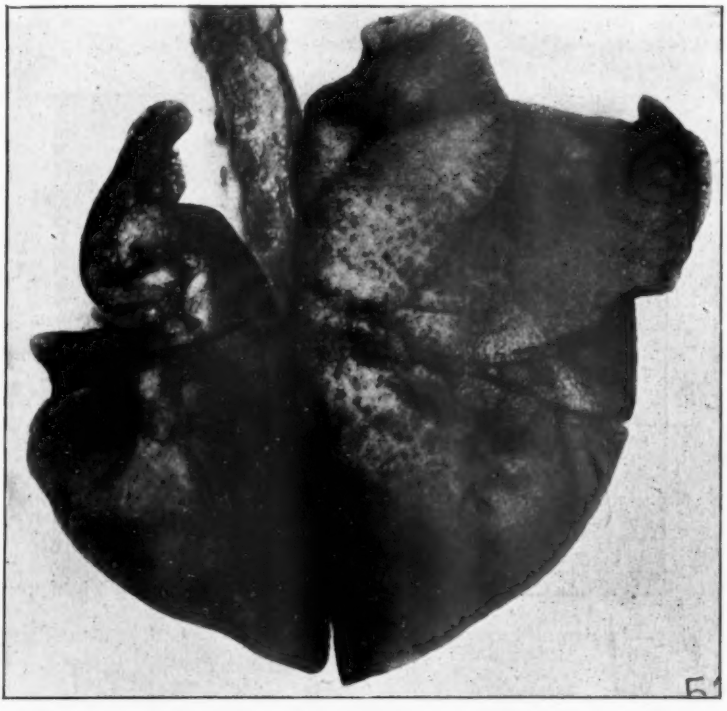

FIG. 8.—Lungs of a rabbit 20 days after exposure to blast. The upper lobe of the left lung is completely collapsed.

in a few cases total collapse of a single lobe has been observed up to twenty days (fig. 8). Pneumonic consolidation, with heavy monocytic and polymorphic infiltration, also occurs.

(2) *Factor responsible for pulmonary hæmorrhages.*—Although they have not investigated the problem experimentally, previous observers have speculated about the manner in which the pulmonary lesions are caused. Three possibilities have been suggested.

The first is that the lesions are due to the lowering of alveolar pressure by the suction wave, acting through the respiratory passages, with the consequent rupture of the alveolar

capillaries. This possibility is suggested by Logan (1939), by Shirlaw (1940, p. 41), and in reports of French shelter tests. It is also the view which is often stated in discussions of the casualties that occurred in Spain. The second possibility is that the lesions are caused by the "sudden distension of the lungs with air" rather than by "external pressure on the ribs" (Report on Sectional Steel Shelters. Physiological Section. H.M. Stationery Office, 1939). The third possibility is that the lung lesions are due to the impact of the pressure wave on the chest wall. This view is advocated by Hooker who writes with reference to experiments on frogs: "It is wholly improbable that lowered pressure could distend these organs sufficiently to cause their rupture. On the other hand a sudden elevation of pressure retarding the expulsion of air through the trachea and forcibly compressing the body walls could readily rupture these delicate organs." The same belief about the cause of the injury is stated by Kretzschmar (1940) in his recent clinical description of blast casualties in Spain.

Our own experiments suggest that the last of these possibilities is the correct one, and that internal injuries due to blast are mainly caused by the impact of the blast wave on the body wall.

Thus experiments in which animals were exposed to blast from the explosion of charges of hydrogen and oxygen in balloons showed that lesions are bilateral when the animals are placed some distance from the explosion, and mainly, if not entirely, unilateral when

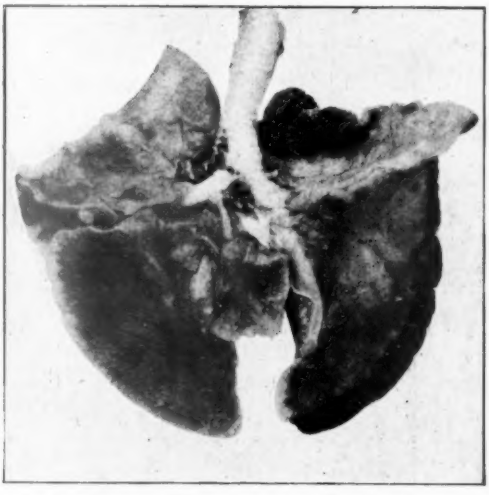

FIG. 9.—Lungs of a rabbit exposed close to the explosion of oxygen and hydrogen in a balloon. The hæmorrhages are confined to the side closest to the explosion.

the animals are placed so close that one side shields the other (fig. 9). In the latter case the lesions are on the side facing the explosion. This fact (as well as the anatomical sites of election of the hæmorrhages) suggested that the lesions are caused by the impact of the wave on the body wall. It could hardly be interpreted in any other way. For if blast affects the lungs through the respiratory passages, either by reducing alveolar pressure or by suddenly distending the alveoli with air, it is impossible to explain why animals placed close to the balloon explosion sustain damage to one lung only, and to the lung on the side facing the explosion. This consideration seems to render untenable views which regard the effect as indirect and not direct. One indirect view which has been tested is that the lesions are due to back pressure in the pulmonary circuit. Experiment showed,

however, that while small scattered hæmorrhages do occur in the lungs, following ligation of the aorta, the lesions are bilateral and different in disposition from those seen in animals exposed to blast. A further and important consideration, which suggested that the lesions cannot be due to any pressure changes occurring directly by way of the respiratory passages, is the observation that in some circumstances lesions due to blast may occur in almost every abdominal organ (*see below*).

The hypothesis that the lesions are due to the impact of the blast wave on the body wall was confirmed in a first set of experiments which showed that rabbits that are thickly clothed in sponge rubber jackets receive no pulmonary damage, or very slight damage compared to controls. In a further set of experiments, rabbits were exposed to blast from balloon explosions with only one side of the trunk clothed in this way, the animals being placed as close to the balloon as was possible. Those animals which were exposed with the uncovered side facing the explosion suffered severe damage to the lung on that side, and less severe damage to the lung on the opposite side. Those animals which were exposed with the clothed side facing the explosion suffered no damage, or very slight damage to the lungs. In yet a third series of experiments, rabbits were placed in specially made wooden boxes with only their heads exposed, and arranged at distances from a

FIG. 10.—Hæmorrhages in the epicardium of the heart of a monkey that had been exposed to blast.

charge which usually proves fatal, and at which severe pulmonary lesions are always found. The boxes did not stand up to the blast, but in those cases in which they were only slightly damaged, pulmonary hæmorrhages were slight or absent.

Although these many considerations show that it is the pressure component of the blast wave which is the factor responsible for internal injuries, it is not impossible that, once the lungs have been bruised by the impact of the pressure wave, the suction wave could add to the damage by pulling the chest wall outwards and thereby stretching the lung tissue (which would follow the movement of the chest wall).

(3) *Other thoracic organs.*—Small hæmorrhages are occasionally observed in the

thymus and pericardium, and more rarely in the epicardium (fig. 10). A fairly constant feature associated with sudden death due to blast is right-sided dilatation, but no changes have as yet been found microscopically in the myocardium or endocardium of animals exposed to blast. A hæmopericardium was observed in one case.

Hæmorrhage is occasionally observed in the intercostal muscles, but none has been seen in the subcutaneous tissues or muscles of the pectoral girdle.

(4) *Abdominal organs.*—About 40% of all animals examined (all of which had pulmonary hæmorrhages) showed hæmorrhagic lesions in various abdominal organs. Two-thirds of the 40% had been killed by the blast to which they had been exposed. The severity of abdominal lesions does not appear to be correlated with survival, and in general abdominal organs are much less sensitive to blast than the lungs.

The most susceptible abdominal organ is the large intestine, where the lesions appear as patches of hæmorrhage varying from small points of bleeding in the subserosa to large annular bands of hæmorrhage, and even rupture (fig. 11). The small intestine and stomach are less frequently affected.

The liver may be bruised, and occasionally torn ; in some animals the surface of the right lobe may be marked by lines corresponding with the ribs. Hæmorrhages are more rarely observed in the spleen, kidney, adrenal, and bladder, which in one case, however, was ruptured. By chance some pregnant guinea-pigs were used in one series of experiments. Hæmorrhages were observed in the uterine wall, and in the upper parts of the fœtuses.

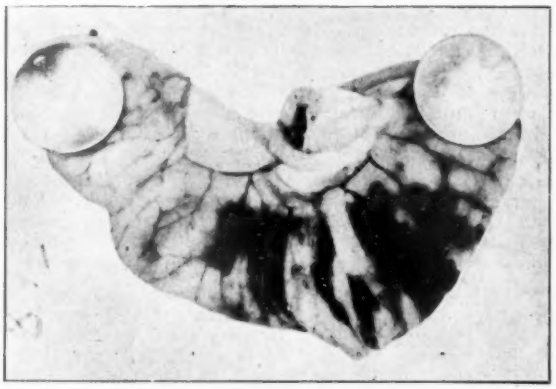

FIG. 11.—Hæmorrhages in the small intestine of a monkey that had been exposed to blast.

Small blood-clots have sometimes been found in the peritoneal cavity, and retro-peritoneal hæmorrhage has also been seen. Foci of hæmorrhage are not uncommon in the mesentery.

(5) *Head and neck.*—Hæmorrhages have occasionally been observed in the fascial planes of the orbital cavity, but not in the eyeballs themselves. Rupture of the ear-drums has also been often observed in animals exposed to high pressures. Hæmorrhages have been found in the paratracheal fascia, and more frequently in the trachea itself, where they are mainly localized in the submucosa.

(6) *Nervous system.*—Particular attention has been paid throughout our investigations to the occurrence of nervous lesions. The brains of rabbits exposed in our earliest experiments were examined by Dr. Greenfield ; no changes which could definitely be ascribed to blast were found, a conclusion that was also reached by Professor Le Gros Clark in an independent study of another series of brains. A larger series of animals,

that had been exposed to higher blast pressures, has since been studied, and the following is a brief statement of the more important findings.

No changes were observed in the cortex, mid-brain, pons or medulla of monkeys subjected to pressures as high as 110 lb. per square inch. On the other hand, most monkeys exposed to high pressures show extradural hæmorrhages in the thoracic spinal roots, which are sometimes continuous with hæmorrhage along the intercostal nerves. In two animals that died hæmorrhage had occurred at the central ends of the posterior columns, and in the dorsal commissure. Furthermore, most animals have shown a zone of œdema, absent in controls, around the central canal, especially in the thoracic region but also in the cervical and lumbar cord. This œdema may involve both anterior and posterior commissural fibres.

Changes in nervous tissue are more pronounced in rabbits exposed to high pressures. Pial hæmorrhages occur on the surface of the cortex, and hæmorrhage from the tela choroidea, filling the ventricles, has been observed. Hæmorrhages have not been seen, however, in either the grey or white matter of the brain.

Spinal-cord hæmorrhages are of the same kind as, but more severe than, in the monkey.

It is conceivable that as a result of these lesions the sympathetic outflow may be interrupted, and that sensory defects may occur as a result of œdema and pressure on the commissures.

(7) *The effect of blows on the body wall.*—It has long been known that severe falls, or a blow from a fast-moving vehicle, or a direct blow, may damage thoracic and abdominal organs without causing any penetrating injury. Moreover, traumatic pneumonia has long been recognized as a clinical entity. Thus Morgagni described lung bruising which resulted from a fall off a horse, and Gosselin in 1847 devoted a paper to the subject. More recently the problem has been reviewed by Fischer (1912), and detailed papers describing the condition have recently been published by Fallon (1940) and Osborn (1940). Furthermore, it may be noted that both Courtois in 1873 and Külbs in 1910 showed experimentally that pulmonary hæmorrhages occur when the chest-wall of animals is struck by a mallet.

It follows, therefore, that the pulmonary lesions due to blast are at least partly comparable with those caused by direct blows on the body wall. This fact is important, as is shown below, because air-raid victims are more usually subjected to indirect blast effects such as violent displacement or the impact of flying and falling masonry than they are to the blast wave itself.

Blast as a Factor Causing Casualties

These experimental findings indicate the kind of injuries that are to be expected as a result of the direct action of blast on the body. In air raids, however, the circumstances in which blast acts are very unlike the experimental conditions that have been described. In the first place the explosive is contained in metal, and part of the energy of the explosion-gases is absorbed in shattering the casing. Splinters and secondary missiles are sent flying, buildings are blown up, houses collapse as a result of ground shock-waves; these and many other structural effects all conduce to injuries. In order to see where and how blast of itself can injure it is therefore necessary to define the circumstances under which injuries may occur in air raids. The classification that we have found useful in our casualty survey is as follows:—

Primary

Effects due to.—(1) (*a*) Being hit by splinters; (*b*) being affected by the impact of the blast wave (e.g. effects on the lungs and ears); (*c*) being burnt by the flame of the explosion; (*d*) (possibly) being poisoned by C.O. liberated by the explosion in enclosed spaces; and (*e*) (possibly) in the remote chance, being hit by the bomb itself.

Secondary

Effects due to.—(2) (*a*) being thrown by the blast wave against a hard surface: (*b*) being bowled over as a result of a splinter wound.

Tertiary

Effects due to.—(3) (*a*) Being hit by secondary missiles, e.g. flying masonry, wood, furniture, glass, girders, &c.; (*b*) having walls, floors, ceilings, fall on one, either as an

immediate effect of an explosion or as a result of collapse due to an earth shock-wave; burial under debris; in steel shelters, being crushed by the caving-in of the shelter; (*c*) falling, through being knocked, other than directly by blast, from a raised position, or through the collapse of a floor; and (*d*) (possibly) the impact of an underground wall violently accelerated, but not broken, by an earth shock wave.

Quaternary

Effects due to.—(4) (*a*) Asphyxiation; (*b*) carbon monoxide poisoning; (*c*) burns; and (*d*) drowning.

The primary effects of blast will be experienced only very close to an explosion—for example, when a bomb bursts within an inhabited room or shelter. Furthermore, except with large bombs, the primary effects of blast are hardly likely to be experienced further than 20 ft. from the bomb. This danger zone for blast is obviously, too, the most dangerous zone for splinter wounds.

The radius within which primary blast injuries may be expected will be further limited by the circumstances under which the explosion occurs. Thus, when a bomb detonates after it has penetrated into the ground, so that a deep crater is formed, the blast is mainly directed upwards in an expanding cone, and people standing or lying close to the lip of the crater will be protected from the wave of increased atmospheric pressure. Furthermore, when a bomb detonates close to walls, the blast is reflected, and its energy absorbed in odd ways, so that people situated near-by may escape the impact of the wave. Again, as already mentioned, the front of the blast wave close to the bomb is irregular, so that people situated at the same close distances may be subjected to different pressures. This fact helps to explain certain instances in which individuals have escaped injury. For example, in one case that was investigated eight men were together in a single story room 20 ft. by 16 ft. in which a bomb exploded slightly above floor level (having apparently bounced). Of the eight, five were killed and three survived; all three, however, developing symptoms indicative of lung injury.

In general it may be said that, of the total number of people thus far injured in air raids, only a small percentage will have been exposed in circumstances where they would have been affected by the blast wave in such a way as to incur the injuries that have been discussed above.

Fatalities due to blast have, however, already been reported and many more must undoubtedly have occurred. The difficulty arises in their diagnosis. One case has been described by Falla (1940), another by Osborn (1940), and several by Hadfield, Ross, Swain and Drury-White (1940). Falla's case is that of a man who was in a workshop in which a bomb exploded some 45 ft. away from him. This casualty received a large lacerated wound of his right thigh, and died some twelve hours later. Post-mortem examination revealed many small fresh hæmorrhages on the surface of the lungs, and scattered points of hæmorrhage throughout the substance of the lungs—"a miliary condition of fresh hæmorrhages". Microscopic examination revealed fairly generalized arteriolar dilatation, and intense focal capillary dilatation, with exudation of fluid into many alveoli. In a few places the lung tissue was disrupted and free blood-cells were present in the alveoli, the small bronchial tubes, and the interstitial tissue. In Osborn's case the casualty, a girl of 17, was in a house that was demolished by a high explosive bomb. She showed some external injuries and had a fracture of the skull. A blood-stained effusion was present in both pleural cavities, and the large air passages were filled with blood-stained froth. Both lungs contained multiple small hæmorrhages. A few larger hæmorrhages were also present, and there was a wedge-shaped zone of hæmorrhage 9 cm. long on the inferior border of the left lung, i.e. that part which fits into the phrenico-costal sinus. The spleen was also torn, and there was some intraperitoneal hæmorrhage. The cases described by Hadfield and his collaborators were members of a group of ten air-raid casualties; gross traumatic lesions were either absent or trivial in all but one case. One, a man of 45, was found dead in a public shelter which received a direct hit. There were irregular hæmorrhagic areas throughout both lungs, but no other injuries. A second was a man of 81 who survived ten hours after he was rescued from the debris of a collapsed shelter. Frothy blood-stained mucus was present in the upper respiratory passages, and areas of irregular hæmorrhage were present in the substance of both lungs. There were no other injuries. A third was a woman of 29 who was extricated from a

demolished house. Externally she showed a contusion of the scalp and multiple lacerations of both the upper and lower limbs. She had surgical emphysema of the tissues of the neck, the mediastium and pericardium, and a fractured skull. The only other injuries found were ill-defined areas of recent hæmorrhage in both lungs. A fourth was a child aged about 2 years who had numerous external wounds and a penetrating wound of its chest wall. The upper respiratory passages contained frothy blood, and there were areas of hæmorrhage throughout both lungs. A few small hæmorrhages were also present on the posterior part of the liver. The other six cases described by these authors also showed pulmonary hæmorrhages, and in three the blood was heavily saturated with carbon monoxide.

The clinical and experimental literature, as already noted, contain many examples of corresponding lesions produced as a result of the impact of the body either with the ground or with a rapidly moving solid body. The conditions of air raids provide only too many opportunities for such impacts. At pressures slightly lower than those which will cause direct effects upon internal organs, blast may act as a very strong wind, and is able to throw

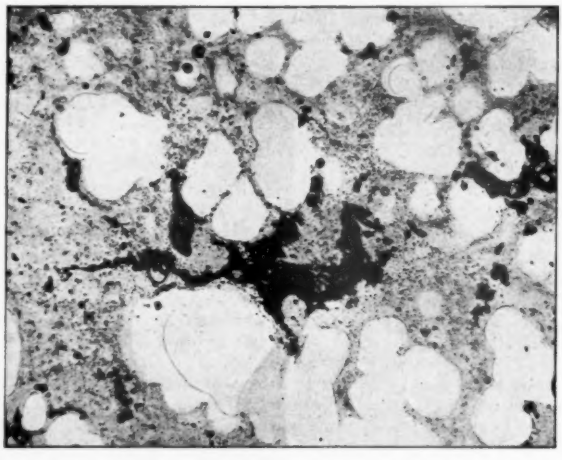

FIG. 12.—Section of the lungs of a woman killed in an air raid. The casualty was extricated from the remains of her house, and autopsy revealed numerous hæmorrhages in both lungs. The specimen has been stained with scharlach R. (black regions) to demonstrate fat. × 58 (H.L.5).

people relatively considerable distances ; when a person is violently thrown against a hard surface, injuries to internal organs may occur. During air raids, again, people are struck by flying or falling masonry, or are compressed by the debris of a house, or fall from an elevated position due to its collapse. All these circumstances may result in internal injuries, and particularly in lung bruising of the sort that has been described in these post-mortem reports. In a recent paper, Robb-Smith (1941) gives a record of 115 fatal accident cases, of whom 20 showed pulmonary hæmorrhages unassociated with penetrating chest wounds. Only one of these 20 was an air-raid casualty, and Robb-Smith states that the pulmonary hæmorrhages that have hitherto been described in air-raid casualties are no different from the hæmorrhages following severe blows and falls. He also suggests that "pulmonary symptoms which arise from exposure to the blast of high explosive may be due to a combination of pulmonary concussion and fat-embolism". Repeated observation has failed, however, to reveal fat emboli in the lungs of animals exposed to blast, and it must there-

fore be assumed that fat embolism does not play a part in causing lung lesions in animals exposed to blast alone. It might do so in those clinical cases in which the primary effects of blast are complicated by violent falls and by the impact of falling or flying masonry, or in which lung lesions can be ascribed entirely to the latter circumstances (fig. 12).

The conditions which in air raids predispose to internal injuries without penetrating wounds are so numerous that care should be exercised before it is decided that any instance of lung hæmorrhage is either partly or wholly due to the direct effects of a blast wave. This precaution was amply brought home to us in an analysis of ten autopsies that were made in the course of a casualty survey for the Research and Experiments Department of the Ministry of Home Security where, so far as possible, every circumstance relating to the incidents in which the casualties occurred was known. All ten cases were instances in which people were very close to bomb explosions, and all had either no external or only trivial external injuries.

Of the ten, seven demonstrated hæmorrhages in the lungs, but of these seven only one had apparently been affected by the blast wave of the explosion alone. All the others were either also struck by secondary missiles, injured through being violently thrown, or buried under debris. The following are three typical cases:—

Case 1.—A woman, one of 13 occupants, was sitting in a shelter about 14 ft. from the point of detonation of a bomb outside. The bomb blew in the upper part of the near wall of the shelter, and blew away the whole of the roof. The fatal casualty was picked up dead from the side of her seat. Her only external injuries were some small skin-deep bruises around her right breast. Opposite these bruises were some hæmorrhages in the parietal pleura, and opposed to this parietal hæmorrhage was a patch of hæmorrhage on the costal surface of the right lung. There was also some hæmorrhage along the posterior border of the same lung; the opposite lung was normal. Her only other injury was rupture of an ear-drum.

Case 2.—A woman was killed in a steel shelter that was displaced 30 ft. by a "near miss". The woman was removed from the remains of the shelter (by which she was not trapped) but died on her way to hospital. She showed no external signs of injury, but a simple fracture was found at the lower end of her right femur. At autopsy the pectoral and intercostal muscles on both sides were found to be much bruised, and about two pints of blood, for which no source was discovered, were found in the right pleural cavity. The right lung was normal. The left pleural cavity also contained some blood, and the base of the lung was almost consolidated with hæmorrhage. Microscopic examination revealed a gradation of hæmorrhagic lesions ranging from small isolated patches to large areas completely consolidated with blood (fig. 13).

Case 3.—This was a man of 48 who died twenty-four hours after he was exposed to the explosion of a bomb. He was 6 ft. from the explosion, and slightly to one side of an open door on the other side of which the bomb exploded. He was neither trapped by debris nor hit by secondary missiles, and his only external injuries were slight abrasions on the fronts of both legs. About a pint of blood was found in each pleural cavity, and extensive subpleural hæmorrhages were found on the mediastinal surfaces of both lungs. The root of the middle lobe of the right lung and the posterior part of the left lung were torn. There were extensive internal hæmorrhages in both lungs. The pericardium and heart muscle were also bruised. Rupture of the spleen and a tear in the liver had led to intraperitoneal hæmorrhage. Parts of the large gut were bruised, and the right adrenal gland was ruptured and hæmorrhagic.

All three casualties were sufficiently close to the explosion for their injuries to be attributed, at first sight, to the direct effects of blast. In only the third, however, could this have been the main cause of injury. In the first the localized character of the pulmonary hæmorrhage in relation to a skin bruise suggests that the lung lesion was due to the impact of masonry—although rupture of an ear-drum suggests that blast may have played a part. If it did it is remarkable, however, that other occupants of the shelter escaped unhurt. In the case of the "near-miss" on the steel shelter, again, there were three other occupants who were not killed. One escaped without any injury, the second received a minor injury, and the third a serious injury. In this incident the bomb exploded after it had penetrated into the earth and left a fairly deep crater. In such circumstances, as has already been pointed out, the blast wave is mainly directed upwards in an expanding cone. The woman who died was subjected to violent displacement when the shelter

was blown 30 ft., and her lung injury may have been sustained in that way. On the other hand, the possibility that she may have been directly affected by blast cannot be excluded, for it is conceivable that she was just within, and the other occupants of the shelter just outside, the cone of blast.

It has become increasingly obvious that, to determine the lethal factors in any given incident, it is essential that as detailed information as possible must be available about the ways casualties occur. Hæmorrhages in the lungs, as has been emphasized already, cannot be regarded as an exclusive sign of the direct action of blast. It is useless to speculate how many deaths may have been due to the direct effects of blast alone; on the other hand, it can hardly be doubted, on the basis of available evidence, that lung bruising is at least as frequently a secondary or tertiary as a primary effect of blast, and that it may be a combination of all three.

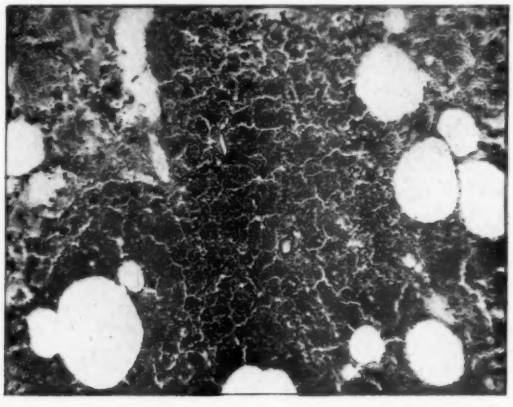

FIG. 13.—Low power view of lung of a woman killed in a steel shelter as the result of a "near miss". There was massive hæmorrhage throughout the left lung. × 58. (H.L.3.)

In the earlier stages of our experimental work, and before any results had been obtained from casualty surveys, it had been assumed *a priori* that, with widespread bombing, instances of non-fatal lung damage were likely to exceed in number fatal cases "even though neither may prove to be relatively common" (Zuckerman, 1940). Under the special conditions that prevail in ships this forecast may prove correct (Dean, Thomas and Allison, 1940), but it would seem to have been unduly pessimistic so far as civilian casualties are concerned. Up to the present, few cases have been reported of air-raid casualties who have been treated for internal injury due to blast. The following are two clear-cut cases of some that have so far been brought to our attention. The first is that of a man who was in the open when he was bracketed by three heavy calibre bombs. The furthest any bomb was from him was about 25 yards. He was thrown down by the blast, but not rendered unconscious. He noticed a sprinkle of blood on his glasses, but apart from psychogenic shock no other symptoms. He got up on all fours, and was immediately knocked over by the blast of another smaller bomb. He lay on the ground for a few minutes in the lee of a hut, and some wooden slats from the roof fell on him. The blow was slight and (both according to him and his medical officer) would have been regarded as trivial in normal circumstances. It left a slight bruise. The casualty then crawled into an air-raid shelter 5 or 6 yards away, where he started to cough up blood. He remained in the shelter for ten minutes, and then ran to perform the duties which were interrupted

by the raid. During the next two hours his condition became worse, and he was then admitted to hospital. No physical signs were present in his chest, but shortly after admission he spat up some blood. X-ray examination revealed some shadows and mottling in the lower part of the right lung, similar to the conditions observed experimentally. The patient remained in hospital for sixteen days, during which repeated radiographs showed that the lung condition was clearing up. Recovery was uneventful.

The second case is that of a man who was sleeping on a divan bed next to a wall. A bomb exploded in a room about 12 ft. away. The wall was blown into the next room, and he and the divan were also blown for a few feet in that direction. He was immediately brought into hospital where perforation of one ear-drum was discovered. There were no external injuries of any kind. The patient suffered from slight hæmoptysis and complained of a sense of "tightness" across the lower chest and shortness of breath, with pain at both bases on deep breathing. Physical signs were absent, but an X-ray revealed congested bronchial markings with patchy consolidation on the right side.

These two histories indicate primary effects of blast, for it would seem that what direct trauma was experienced was too slight to have caused lung changes by itself. They also point to the advisability, in diagnosing injuries directly due to blast, of combining with clinical study and X-ray examination careful analysis of the circumstances under which the injuries occurred.

One point that should not be overlooked in reaching a diagnosis of blast injury is the occurrence of ruptured ear-drums. Though apparently infrequent in air-raid casualties, perforation of the tympanic membrane is to be expected in those who have been exposed sufficiently close to explosions to have suffered internal injuries as a result of the direct action of blast. In reaching a diagnosis particular attention should also be paid to the occurrence of external injuries. By itself blast will not cause external bruises (except, of course, when an individual is close enough to a bomb to be "blown to pieces"), and external bruises associated with chest symptoms may indicate lung bruising at least partly due to indirect effects of blast. Although the present evidence does not suggest that they will be conspicuous, attention should also be paid to signs indicating nervous lesions.

In conclusion two points may be re-emphasized. The first is that fatal casualties with little or no external sign of injury will probably only in rare instances have died from the direct effects of blast alone. Other causes of death in such circumstances are asphyxia following burial under debris, carbon monoxide poisoning, and death from chronic diseases aggravated by sudden shock. Whether blast can cause death as a result of a sudden nervous crisis is a matter which at present is only open to speculation.

The second is that bruising of the lungs may occur not only as a result of the direct action of blast, but also as a result of secondary and tertiary blast effects such as violent displacement, and the impact of flying and falling masonry.

So far our experimental work has given no clear indication of the cause of death in animals which die immediately as a result of the impact of a blast wave. Pulmonary lesions cannot always be regarded as responsible. This problem, amongst others, is now under investigation.

Summary

(1) Without causing external injury, the blast of high explosive may cause hæmorrhagic lesions in various internal organs of experimental animals. The most conspicuous lesions are found in the lungs, where they vary, according to the pressures to which animals are subjected, from small superficial hæmorrhages to hæmorrhage which affects the entire substance of the organs. Hæmorrhagic lesions have also been observed in the pericardium and epicardium, the thymus, the liver, spleen, intestine, kidney, adrenal, bladder, and uterus. Hæmorrhagic lesions are also observed in the submucosa of the upper part of the trachea. Hæmorrhages around spinal roots, especially in the thoracic region, are constant, and pial and ventricular hæmorrhages on and in the brain, occasional, at high pressures. Rupture of the ear-drums has also been observed at high pressures.

(2) Experiment has shown that the thoracic and abdominal lesions are due to the impact on the body wall of the pressure component of the blast wave, and not to any effect of the suction wave acting directly through the upper respiratory passages. The pulmonary lesions directly due to blast are thus comparable to some extent with hæmorrhagic lesions which may occur as a result of severe falls or direct blows on the chest wall.

(3) In air raids people are exposed not only to the direct effects of blast but also to indirect effects such as violent displacement and the impact of falling or flying masonry, both of which may lead to pulmonary hæmorrhages. Observation has shown that the direct effects will be experienced only very close to the explosion. Case histories are analysed, and it is suggested that, before diagnoses of internal injuries directly due to blast are made, attention should be paid to the possibility of internal injury due to indirect blast effects.

We have been greatly helped in the research on which this paper is based by the Chief Adviser and the Officers of the Research and Experiments Department, Ministry of Home Security, and by the Director and Officers of the Road Research Laboratory, D.S.I.R. Our thanks are also due to Professor F. R. Fraser, Director General of the E.M.S., and to Ministry of Health and Hospital Officials for making available to us case histories of people injured in air raids; and in particular to Drs. C. P. Oliver, E. L. Martyn Lobb, and F. Dudley Hart for particulars about the two non-fatal instances of direct blast injury referred to in this paper, and to Mr. Geoffrey Parker for information about several fatal cases.

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Professor Geoffrey Hadfield : The best way I can contribute to this discussion is to give an account of a series of post-mortem examinations on cases which were considered clinically to have died from blast. All the hard work in connexion with this investigation was carried out by my colleagues, Dr. Joan Ross, Dr. Swain, Dr. Jordan and Dr. Drury-White and I am merely acting as their spokesman.

The number of post-mortem examinations we have carried out is thirty. We know very little about the " incidents " which caused these fatalities so that I cannot be certain that in any of them the effects were due to blast alone, but an account of them may give you some idea of the pathological changes found in people who are discovered dead without any significant external injuries after close exposure to the detonation of high explosive.

Of the thirty cases, seventeen had multiple bilateral pulmonary hæmorrhages with little or no significant injury to the thoracic wall. Of these seventeen cases, four showed between 50% and 75% saturation of the blood by carbon monoxide. Thirteen of the thirty cases in the series considered from circumstantial or clinical evidence to have died from blast showed no clear evidence of this. Two of them died from compression asphyxia and three from asphyxia due to the inhalation of finely-divided chalk, plaster or brick dust, whilst the remaining eight cases had either severe internal trauma or advanced medical diseases sufficient to account for the fatal issue.

As we purposely narrowed down our investigation to cases thought to have died of " blast " alone, this small series of post-mortems gives one no idea of the frequency of pulmonary hæmorrhages in those who sustain gross surgical trauma. With regard to the pulmonary hæmorrhages, I see no essential difference between the human lesions in these cases and the lesions which Professor Zuckerman has described in the experimental animal. We found in the human cases that the hæmorrhages were frequently deep in the lung and occasionally gave relatively little indication on the surface that they were so extensive below. We tried to satisfy ourselves whether the hæmorrhages seen on the outside of the lung were related to the ribs, and sometimes this did appear to be so, but quite often we could not substantiate that idea.

Sections taken through the hæmorrhagic areas show that the blood lies almost exclusively in the alveoli and that its source is the alveolar capillary network. We have been struck by the disproportion between the amount of blood in the alveoli and the relatively slight damage to the alveolar walls themselves. There is always a considerable degree of generalized dilatation and congestion of the capillaries of the alveolar walls and this change is also found in non-hæmorrhagic areas of the lungs. Relatively little blood lies in the airways, but there is always considerable dilatation of the alveolar ducts and respiratory bronchioles. I mention that because a good deal of the clinical picture which these patients present when they survive the incident may possibly be due to widespread capillary dilatation.

The other thing that struck us on reviewing our cases was that the amount of hæmorrhage into the lung in fatal cases varied within very wide limits. I am able to show you some tracings obtained by placing tracing paper over the lung and marking out the areas of hæmorrhage. Quite a large amount of the hæmorrhage is deep in the lung and where the blood approaches the pleura one gets apparent subpleural hæmorrhages. The areas of hæmorrhagic consolidation are quite elastic in their consistence. In one case which died rapidly the hæmorrhages are much smaller than in another in which the patient survived for some hours. I should like particularly to emphasize this finding, because in a moment or two I want to show you the tracing of a lung in which the hæmorrhagic areas are very much larger. This was a case which survived the bombing for about forty-eight hours. We feel that if a case does recover from the initial explosion it is probable that bleeding continues into the lung, so that the cases which survive show very much larger areas of hæmorrhage than do those who are found dead at the site of the incident.

The next tracing is from the lung of a patient who survived exposure to the detonation for fifty-one hours. (Not illustrated.) The lower lobe shows widespread hæmorrhagic consolidation, in which there are many small areas which at post-mortem were ashen grey in colour. These areas present a histological picture which is very suggestive of a pneumonic process. At the periphery of the areas of hæmorrhagic consolidation there were broad irregular zones in which the bleeding was quite fresh. These zones were bright red

in colour. Both lungs showed these zones of recent hæmorrhage disposed around the periphery of darker coloured areas of hæmorrhagic consolidation.

The patient surviving exposure to detonation for the longest period also showed the most extensive intra-alveolar hæmorrhages. He survived for fifty-one hours and we believe that during that time he continued to bleed into his lung. This view has an obvious importance from the point of view of treatment, and I will mention his clinical story. The histological picture of the lung in the scattered areas of pseudo-pneumonic consolidation shows all alveoli to be filled with a fibrinous exudate in the meshes of which are large numbers of wandering cells. The general appearance of this part of the consolidated lung is reminiscent of lobar pneumonia, but under higher powers many of the wandering cells are seen to be mononuclear. This rather strange pseudo-pneumonic consolidation lying in big patches of resolving hæmorrhage is a very striking feature and it may affect considerable parts of the lung.

Here is the clinical story of the patient who lived for fifty-one hours. He was aged 23, and was asleep in a wooden hut when it was demolished by a large bomb. He was not buried and he sustained no external injury. He was admitted to hospital about two hours afterwards, suffering from shock and pain in the chest and abdomen, and he vomited some blood-stained fluid. The abdomen was rigid and very tender. Twelve hours later he was still vomiting, the abdomen was still tender and there was now an impaired percussion note over the left base. The respiration rate was 36 and the blood-pressure 126 mm. Hg. He was drinking fluid freely but vomiting large quantities. Tenderness over the abdomen and chest continued, and there were many râles over the lungs. At the end of forty-three hours the hæmoglobin was 125 and the blood urea 85 mgm. Forty-four hours after the incident 600 c.c. of blood was withdrawn by venesection. The patient became quieter, respiration much easier and the râles in the chest were considerably less. This striking improvement was maintained for three hours, when the respiration rate again rose, the pulse failed, and death occurred fifty-one hours after the incident. This patient developed a syndrome which may quite well have been due to generalized capillary congestion of the lesser circuit, and most of his urgent symptoms were relieved by venesection.

We do not wish to insist that the cases investigated have arisen as pure effects of "blast", but all of them showed fairly extensive pulmonary bleeding associated with widespread dilatation and congestion of the alveolar capillaries. We think it worth while considering whether a good deal of this intrapulmonary capillary bleeding may be due to diapedesis. We consider that the bleeding goes on for a considerable time and, on the basis of the case I have described, that it may continue for at least fifty-one hours following the incident. We find it difficult to believe, having in mind the histological picture of these lungs, that the capillary rupture does account for all the capillary bleeding. If the histological picture be combined with the clinical findings in life it is rather more easy to explain the latter on the basis of generalized vasodilatation of the whole lung on both sides than to bleeding itself. It seems to us that the major clinical manifestations are more probably due to capillary dilatation of the lung than to the actual bleeding into the lung, which may be a consequence of capillary dilatation.

There is a specimen of sputum on the table which we thought of interest because the patient in this case was subjected to what appeared to be the effects of blast, and has now almost recovered. He was in a wooden building which sustained a direct hit. He showed no external signs of injury and recovered in the course of a few days from his more urgent respiratory symptoms. That was some seven weeks ago. Since the incident he has had four attacks of hæmoptysis, one as recent as the day before yesterday. Thus it is possible that one result of the detonation of high explosive is that the lung is left in such a condition that it is liable to bleed intermittently for some considerable time after the injury.

My contribution to this discussion, founded as it is on human material, is rather premature. The opportunities for getting suitable material for investigation are few and it is very difficult to reconstruct the incident. I should like to qualify what I have said by pointing out that it is founded on very short experience, but we do feel inclined to express the opinion that following exposure to the detonation of a high explosive, bleeding into the lung may continue for a period of days. If this belief is substantiated it must, of course, have an influence on treatment. It means that these patients should be immobilized as if they had had a recent large hæmoptysis and it may

be that disregard of this precaution may explain why some cases, which have been exposed to detonation and have apparently recovered from the initial respiratory embarrassment, have subsequently relapsed.

Dr. J. N. O'Reilly said that he had been able to investigate some cases who were in a wooden building which was demolished by a very heavy bomb. One clinical point emerged from the cases he was able to observe. In two cases within forty-eight hours, and in a third case within five days there were all the clinical appearances of lobar pneumonia. This was rather interesting in view of the histological findings just mentioned. One man had fairly typical "blast" lung, and twenty-four hours after the first X-ray picture was taken—forty-eight hours after the incident—he had a temperature of 103°. He had dyspnœa and pain in the chest, localized in the right lower zone. He also developed tubular breathing. He was treated as an ordinary case of lobar pneumonia with sulphapyridine and made an uninterrupted recovery, and the picture of the lungs showed normal resolution. The second case was a boy aged 19 who was exceedingly ill when admitted—very dyspnœic, very cyanosed, and very shocked, but with no external injury. He appeared from the first examination to have very much impaired air entry at the right base and scattered râles over the rest of the lungs. Twenty-four hours later he, too, had tubular breathing and he appeared clinically to have lobar pneumonia. He was treated with sulphapyridine. Subsequent X-rays taken forty-eight hours later showed collapse of the right lower lobe. He eventually made a complete recovery.

The third case was a little different. This was a man in the same incident who came in complaining only of a little pain in his chest and a certain amount of shock. Within twenty-four hours of the incident he was well except for the chest pain which was centrally placed. On the fifth day he had a temperature (the temperature had never actually settled down but had always been going up to 99° and 100°) of 102°. An X-ray picture was taken and his chest was quite clear. Then forty-eight hours later, he had clinical signs at the right base and a further X-ray showed the usual appearance of lobar pneumonia. He had made a slow recovery but the condition was now almost resolved.

These three men showed as did others what was apparently clinical lobar pneumonia immediately following the incident and apparently caused by pure blast. Professor Zuckerman had rather insisted on pure blast, and it could be said of the three men whose histories he had related that they had no external injuries approaching in any degree those of crush injury. One man did have a lacerated wound on the forehead, apparently the result of tearing by a nail or some such projection ; but he had not been buried.

A second clinical point which he desired to ask about rather than to dogmatize upon arose from the fact that five cases in this same incident were brought in with all the appearances of acute abdominal catastrophe—rigid abdomen, pain, and so on. In two of them the condition was sufficiently serious to require opening up by the surgeon, but when this was done nothing was found, except a few minute subserous hæmorrhages. The abdomen in each case was at once closed up. One of the cases operated on subsequently died. This man in addition to typical blast injuries of the lung, had extrapleural hæmorrhages in his intercostal spaces. When the viscera were removed the inside of the thorax appeared black except for the white bands of the ribs. Whether that had any significance and whether hæmorrhage in that position could cause intercostal nervous irritation and give rise to a rigid abdomen, he did not know.

Dr. J. M. Alston said that a tremendous number of facts on this new subject had been brought forward by Professors Zuckerman and Hadfield and, as might be expected, the experimental approach and the clinico-pathological approach had not quite met so as to form a complete picture. He wondered whether Professor Zuckerman's work had gone far enough in the directions he had indicated to enable him to tell them whether rabbits or other animals which survived the shock experiments did show lesions of pseudo-pneumonia such as those to which Professor Hadfield had referred. That would help to bridge the gap between the two types of work of which they had been hearing.

Dr. Beryl Barsby asked whether Professor Zuckerman had seen any case of blast injury without hæmoptysis. She had had a case unquestionably due to blast which had a spontaneous hæmothorax with X-ray evidence of blast on the other side and ruptured spleen.

Professor Zuckerman said that he had been asked whether there was any evidence of pneumonias occurring in animals after exposure to blast. In this respect Professor Hadfield's clinical observations corresponded closely with the experimental findings. Animals of a group which survived exposure to blast pressure sufficiently high to kill other members of the group sometimes developed pneumonias. The white-cell infiltration associated with the pneumonic process was predominately monocytic.

Experimental findings also coincided with Professor Hadfield's clinical observations in so far as areas of hæmorrhage often appeared more marked in animals killed and autopsied some hours after exposure than in animals that were killed outright by blast. On the other hand, no evidence was available to show that zones of hæmorrhage became more extensive as a result of continued bleeding. In answer to Dr. Barsby it was stated that pulmonary damage due to blast, unassociated with hæmoptysis, was often observed in animals.

Dr. O'Reilly's clinical observation of hæmorrhages in the intercostal space was of interest from the experimental point of view, since similar hæmorrhages were sometimes observed in animals exposed to blast. The hæmorrhages followed the intercostal nerves, and were continuous with hæmorrhages round the spinal roots.

He did not believe that there was any essential difference between the pulmonary lesions that had been described in human air-raid victims and those which had been observed in experimental animals, except in so far as the anatomical distribution of the hæmorrhages appeared to be different. On the other hand, the generalized capillary dilatation which Professor Hadfield regarded as the primary lesion had not been observed in experimental animals. Several hundred lungs had been examined, and the dilatation did not appear to be a primary factor. In the regions where lesions occurred as a result of blast, there was undoubtedly rupture of alveolar walls and disruption of the lung substance. When the lungs were removed at autopsy, areas of hæmorrhage, and occasionally congestion, alternated with areas in which the lung had its normal healthy pink colour.

Without knowing in detail the circumstances under which casualties occurred it was impossible to say that the hæmorrhagic lesions that had been described in air-raid victims were due to blast alone. The question that had to be asked was, how much are they due to the direct action of blast, and how much to the effects of being thrown against a hard object or to the impact of masonry ?

Robb-Smith had suggested in a recent paper that pulmonary fat-embolism is a frequent occurrence in people who die as a result of a violent fall or in a street accident ; and he had demonstrated its occurrence in one victim of an air-raid who died seventeen hours after an explosion. Since fat-embolism was not found in experimental animals exposed to blast, it is conceivable that it is a sign which would allow of differentiation between cases that had been exposed to blast alone and those which had been exposed to blast as well as impact with a hard surface.

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DISCUSSION ON PREVENTION AND TREATMENT OF PARASITIC DISEASES

Some Recent Work on the Louse

By Professor P. A. BUXTON

IT would be true to say that in any sort of applied biology one is always interested in the question of numbers of animals, that is to say, in populations. An agricultural entomologist does not want to know that a certain locust lives in a certain country; the question is a numerical one: are there enough locusts to eat the crops? Similarly the medical officer of health wants to know what part of his population is lousy, whether one race, sex, or age is affected more than another, or whether the incidence is higher at one season than at another.

When transmission of disease is involved this matter of populations is extremely important, because one does not get transmission of disease by biting insects if they are scarce. Take, for example, the disappearance of typhus. No one can pretend that the louse has disappeared from this country, but typhus has. Up to 1880 the deaths from typhus for England and Wales were round about 1,000 a year. By 1890 they had fallen to about 100. After 1910 they were never above 10 in the year, and the last typhus death was in 1918. A number of causes may explain this decrease, including better personal hygiene and a reduction in the numbers of lice, but not by any means their disappearance. The same kind of result has been observed in other places. If one has to deal with an epidemic of louse-carried disease one can bring it to an end by achieving a partial control of the insect.

Six or eight years ago in the London School of Hygiene and Tropical Medicine we began to study populations of lice. We knew that if hair were dissolved in alkaline solutions of sodium sulphide one could recover the cuticles of the lice. We applied that simple technique on a large scale to samples of hair received from a number of places in Africa and Asia. The kind of thing we wanted was unselected samples of the local population; the best material that we could get was from the people admitted to certain jails. The first fifty people admitted each month had their entire scalp shaved and the whole of the hair was sent to us in an envelope with a brief statement as to age, sex, &c. We boiled the hair down with sulphide and took out the infesting lice, if any were present. We have done that with more than 3,000 complete crops of hair, of which 800 or 900 proved to be infested with the head louse. One must admit that our sample comes only from the population admitted to jail, and it is not possible to get a fair sample of the whole population of a country. Nevertheless, if we have the jail figures for a couple of years one can at least say whether there is a seasonal difference in the distribution of head lice, whether members of one racial or religious group are more or less infested than members of another, whether young jailbirds are more infested than old ones, and so on.

What we discovered is that the most important factor influencing the distribution of head lice among people is the weight of the individual's crop of hair. We have shown

with hair from six or seven different places that there is a strong positive correlation between weight of hair and frequency of infestation. The people with heavier crops tend to be more often and also (though that is another story) more heavily infested.

Most of the other factors we have looked into, such as sex, religion, and occupation, seem to be quite unimportant, though at first sight they may appear to have importance. For instance, among people in jail in Colombo, Ceylon, we found differences between members of different religious communities in the matter of lousiness. But this is simply due to differences in customs in cutting the hair; within one group (e.g. those with 10 to 20 grm. of hair), the difference between religions disappears. Although women, in several countries, are more infested than men, that again is probably due to the greater weight of hair they carry.

In several places from which we have received material, children are more infested than adolescents and adolescents than adults. For instance, in Sokoto, in the north of Nigeria, of the boys from 6 to 10 years of age 21% were infested, of those from 11 to 15, 11%, of those from 16 to 20, 11%, and among the men from 21 onwards only 4%. With rising age there is a steady drop, and that is not correlated with hair weight; it is a separate phenomenon.

The abundance of the head louse among the school children in cities in Britain and its rarity in adults is remarkable. I cannot put that down to negligent school children or negligent mothers. I suggest that there may be some difference in resistance to the parasite, a resistance that increases as the host grows older.

Another very interesting point came out of all this work on the crops of hair. If the lice per infested person are counted, it will be found that the number of people who have from 1 to 10 head lice in the crop of hair is commonly about double or even treble the number who have from 11 to 100 lice. There may be a few who have over 100, or, in rare cases, over 1,000. The number of people who have no lice depends on local circumstances, but of those who are infested, about 1 to 10 is much the commonest value in the six or seven places where we have done this work. It is interesting to note that in the last war Peacock observed a similar distribution of body lice in the shirts of heavily-infested men in the trenches, among whom the individual counts were for the most part low. That is curious in a parasite which can multiply as fast as the louse; it means either that people succeed in exterminating their population of lice and then get reinfested, or that the primitive things a man does with brush and comb, though not quite adequate to control the infestation, yet keep it chronically at a very low level.

This work on the head louse as distributed among people in various parts of Asia and Africa has given us information also of a more strictly entomological sort. We know more now about the structure of the louse community, how many males to females, how many larvæ per female, and so on. It would not be suitable to go into that side of the work at this meeting, but it has afforded us information on the louse population considered by itself and without reference to the human host. Among other curious things we find that there are parts of the world in which there are about five larvæ per female on large numbers of heads, while in other parts of the world the number is 10 or 12. We do not know why this is, but it puts us on the way of further understanding the dynamics and growth of the louse population.

All this work that I have mentioned, taking a crop of hair and counting the lice in it, has this against it, that it only tells us the state of affairs at a certain moment; it does not tell us how Nature led up to that state of affairs. One could—and perhaps some day we shall—study that experimentally. Some progress has been made in a different direction. We have placed lice in a box with a gauze bottom, held tightly against the person by some sort of bandage: this is worn and the insects feed through the gauze. Under these conditions we obtain information about the normal length of life of the larvæ and adults, whether the male lives longer than the female, how many eggs the female lays if kept in contact with the surface of the body the whole time; in fact, a considerable body of vital statistics about the louse has been accumulated under these rather unnatural conditions.

I have spoken so far about what might be called scientific work. We have also done some rather interesting work on methods of control—practical applied work. Very shortly after the outbreak of war medical entomologists were much exercised as to what was the most suitable thing to do, and some of us thought that an advance in the way of controlling the lice was one of the things most necessary. A group of us from several

institutions, discussed what could be done ; it seemed that the centre of the problem is that if people are living in a lousy environment (as the troops who were up the line were doing in the last war) then no matter how good the control, one can hardly deal with the situation. In the last war nearly everybody in the front line was infested. A battalion was taken out, rested, cleansed, and sent back. Within two or three days of their return the men were already lousy, and within a few more days they were as lousy as they had ever been. What seemed to be needed was something, applicable to head or garments, which would not only kill lice but remain active for a considerable period. The most promising thing so far available was worked out by two entomologists, Dr. McLeod and Dr. Craufurd-Benson, who started a louse clinic in East London. The agent applied is a finely-ground powder, and a formula has been arrived at, which on national grounds must be kept secret : the material is called A.L.63. If some of this powder is put on the garment and rubbed in it takes an extraordinary amount of shaking to get it out. If one wears a garment so treated not only will the lice die on it, but it will remain lice-free for about a week ; that break of a week might be of great importance if we had to treat people in the shelters. The interruption in the continuity might prevent the louse community from increasing and getting out of hand.

We in the London School of Hygiene and Tropical Medicine started out on a different line, searching for a liquid insecticide, a small quantity of which could be put inside garments. An effective material has been found (again we do not wish to publish the formula) : a small dose of this material applied to a shirt renders it lice-proof for about a month.

Dr. A. M. H Gray : The two groups of animal parasites which concern us most as dermatologists are pediculi and scabies. Problems connected with both of these groups constantly confront us in times of peace, but in war-time they may assume serious proportions and become a menace to the health both of those serving in the armed forces and of the civil population. In this war not only is the civil population faced with death and injury from military weapons, but also with the risk of those diseases which were specially prevalent in the Army in the last war, and of these pediculosis corporis is the most formidable, not in the main because of the skin conditions it produces but because it may transmit typhus, relapsing fever, and trench fever.

Infestation by head and pubic lice raises no new problems to-day. I propose therefore to compare the conditions under which infestation by the body lice and by scabies occur.

In peace-time pediculosis corporis is almost entirely found in the very lowest stratum of society, such as in tramps and the occupants of common lodging-houses. In the last war, under conditions of trench warfare, it became rife in the Army. It was, however, only when men were in the line for prolonged periods that infestation was at its worst ; in rest periods the condition improved, and at the end of the war, when troops were in comfortable quarters, the trouble disappeared with remarkable rapidity. Nor during the war was there any appreciable increase in pediculosis in this country, though men were constantly returning on leave.

Two conditions are necessary for lice infestation : (1) contact with persons or articles already infested ; and (2) conditions favourable for breeding on the person. Where persons in all strata of society congregate together, such as in the trenches or in air-raid shelters, it is possible that one or more persons may be infested and if conditions for breeding are favourable infestation may soon spread. The body louse is a fairly hardy insect and nits can survive for several weeks in clothing, blankets, &c., and will hatch out when temperature conditions are favourable. Once infestation begins in favourable surroundings it tends to spread in geometrical proportion. It is clear, however, from the experience of the last war that conditions favourable for breeding are of far greater importance than chance infestation, otherwise pediculosis would not have died out with the rapidity with which it did at the end of the war and there would have been a great increase among the population at home during the war.

The two factors which favour breeding of lice are : (1) the continuous wearing of clothes for days on end, so that the lice are kept at a constant favourable temperature ; and (2) the failure to wash the clothes at frequent intervals, so that any stray lice or nits may be killed or removed mechanically. It would therefore appear that if persons liable to infestation, such as those who spend their nights in shelters, were to change their clothes at night and have their underclothing regularly washed, the chance of the lice obtaining a

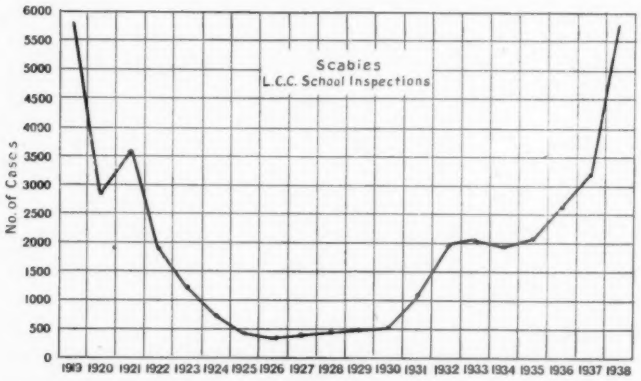
foothold would be small, and that instruction of the public on these facts is most likely to avoid what might become a serious danger to the health of the community.

It is satisfactory to note that, though we have had four months of shelter life, no great increase in pediculosis has been reported, which suggests that the public are keeping up a high standard of cleanliness without any special advice on the matter, though this scarcely absolves the authorities from their responsibilities of making known the facts.

It is, of course, equally important to remove sources of infestation by the compulsory cleansing of persons known to be infested and by the cleaning of shelters and bunks.

It is better and easier for people to change and wash their clothes than to apply to them substances which will kill lice, and if, as I suggest, such simple sanitary measures are capable of preventing lice infestation then use of anti-louse agents should not be required for persons using shelters. The position is entirely different in the case of troops who are compelled for military reasons to wear their clothes continuously for long periods. Here anti-louse agents should be of the greatest value and we all appreciate the valuable work Professor Buxton has done and is doing in this connexion. When I wrote this I had not available to me the full particulars of the extremely interesting method of applying anti-louse remedies which Professor Buxton has just given. I see no reason why these remedies should not be used, provided the ordinary sanitary measures which I have suggested are also carried out.

I now turn to the question of scabies. This disease, although it causes a great deal of skin sepsis, with consequent loss of working time, fortunately does not give rise to serious



Incidence of scabies. Figures from school inspections of children in the London County Council area, 1919-1938.

general disease as does the louse. There is no doubt that it increased enormously during the last war, not only among the troops but also among the civil population. The cases treated in the Cleansing Stations of the L.C.C. during the last war illustrate this: 1914, 589; 1915, 1,059; 1916, 3,213; 1917, 6,940; 1918, 9,624; 1919, 8,371.

MacCormac states that in 1915 it was noticed that many men in drafts arriving in France were affected with scabies and my own observations point to the fact that in the forward areas a great deal of scabies occurred in men returning from leave and in drafts, and that it was not spread extensively in the line. The most striking confirmation of this is shown during the early days of the Army of Occupation in Cologne, when the older troops were being replaced by battalions of young soldiers from England. During February and March 1919, the number of cases of scabies per month rose from about 250 to 900, at a time when pediculosis had practically disappeared.

I have naturally been interested to see how the incidence of scabies has varied since the last war. It is impossible to get figures for the whole population, but it seemed that if one took the figures of scabies as found in school inspections of children in the L.C.C. area it might give some clue to the incidence of the disease among the general population.

Starting in 1919 (the first year in which scabies is shown separately from other skin diseases), the figure is 5,794. This is the first post-war year, when one would expect the figure to be high. After this the number of cases fell, rather rapidly at first, then more slowly, to the lowest figure of 339 in 1926. Since then there has been a rise, first rather slow and then more rapid, to reach 5,768 in 1938 (the last year in which the figures have been published). This is practically the same figure as in 1919. If these figures are any criterion, and they are borne out by those of other education authorities and by the experience of most of us in our hospital clinics, then we are faced with a problem which requires a good deal of thought. What are the possible explanations of this large rise in peace-time? Is it due to better diagnosis? Diagnosis of some cases of scabies can be quite difficult to experienced dermatologists, much more is it, therefore, to the average medical man. No matter how much medical education has improved it is impossible to believe that better diagnosis can have been responsible for such an enormous rise. Is it due to the inefficiency of some of the modern methods of treatment? It is true that many "rapid cures" have recently become popular and many who have little real experience of the pitfalls associated with the treatment of scabies have advertised them freely in the medical press. Some methods, however, are efficient; for example, I have satisfied myself that one-day benzyl benzoate treatment carried out in children under in-patient conditions at Goldie Leigh Hospital, gives as good results as the ordinary three-day sulphur ointment treatment, but it does not follow that equally satisfactory results can be obtained in adults attending out-patient departments. Successful treatment depends more on the way it is carried out than on the preparation used. Further, during the period under review there has been an increasing tendency to report cases to the local M.O.H. so that contacts can be examined and the bedding, &c., properly disinfested: this should tend to diminish the incidence of the disease. I do not think, therefore, that new methods of treatment can be responsible for the increase in scabies.

Has scabies a periodicity? Does its development depend on climatic or environmental conditions? These questions can only be answered by a search into statistics for long periods past. Crocker records an increase in the disease in the United States in the eighties of the last century, but whether this was followed by a fall I am unable to discover.

Lastly, how is the present war likely to affect the incidence of scabies? Under the conditions under which many have to live, one would expect a further increase in the disease, though there is no reason to expect that it will reach unmanageable proportions. It is important, however, that efficient arrangements should be made for treatment and in this connexion the examination and, if necessary, the treatment of contacts and the sterilization of clothing and bedding is essential. It would probably add to efficiency of municipal cleansing stations if the treatment given there was supervised by those who have expert knowledge of the subject.

I have dealt very shortly with two of the subjects which caused us most worry in the last war. Our aim to-day should be to prevent the appearance of pediculosis corporis which at the moment is practically non-existent, but in the case of scabies, which is already with us, early diagnosis and efficient treatment should do much to prevent the secondary skin sepsis, which was another serious worry in the last war.

Dr. H. MacCormac: The Report of the Medical Research Committee and American Red Cross Commission on Trench Fever quotes McNee as having pointed out that 90% of all sickness in one of the British Armies was due to scabies, infections of the skin, and pyrexia of unknown origin, of which trench fever constituted the great majority of cases: or expressed differently, this 90% sickness-rate was attributable to the louse and the Acarus. We are asked to believe that history repeats itself, but this can only be true where circumstances are similar, and it is clear that the present conditions of the Army do not lend themselves to any threat of an epidemic of parasitic skin disease. The repetition of past events may, however, not seem so improbable if we remember that the civilians are now in the front line, and that the conditions of the civilians in the public shelters approximate in some degree to the trench life of the last war, and are, therefore, likely to encourage, among the civilian population, infestation and the consequences of infestation, similar in kind, if not in degree, to those met with among the troops in 1914-18. In a meeting of dermatologists it is perhaps natural that our attention should turn primarily to the condition of the individual and his treatment. There is, however, the far more important public health problem, the threat to the community, and here we are equally concerned, because

the methods of frustration to be employed are closely linked with established dermatological principles. Scabies and pediculosis have little in common in the manner in which they are contracted and spread. Each must therefore be examined as a separate and independent problem.

It is unnecessary to say that pediculosis takes a threefold measure of the human frame, the head, the pubic and axillary regions, and the body. The head louse is usually stated to affect children rather than adults, and although the medical inspection of schools and the fashionable shortening of the hair of women have gone a long way to reduce the incidence, it is, nevertheless, still found by no means infrequently in women of the working and lower middle orders. The degree is usually light, causing little or no inconvenience, so that the infestee is, as a rule, quite unaware of the situation. Every dermatologist is familiar with instances where contamination has taken place by direct contact, or indirectly through caps, hair brushes, or by such things as the cushions of railway carriages. It would seem, therefore, that we have in shelter life ingredients favourable to the spread of this kind of lousiness, which, although more disgusting than dangerous, can in certain circumstances be complicated by impetigo and suppurative adenitis with their sequelæ. This is purely a civilian, not a Service problem, for soldiers do not acquire head lice ; and I have always understood that the practice in the German army of shaving the soldier's head was a preventive measure. In this connexion it should, however, be remembered that this parasite is also capable of conveying typhus and trench and relapsing fever, a quality which may in certain circumstances create for it a very considerable importance. In contrast the pubic louse is the aristocrat of the tribe. Once hatched out it hardly troubles to move from its original position. It is rarely encountered in women, except among strumpets, which may explain its not infrequent venereal origin. It is notorious that in men the pubic louse is more often met with among the better and cleanly classes, leading to a common pitfall in practice, the diagnosis of pubic eczema, the practitioner perhaps forgetting that social eminence is not an exclusive quality, because the louse has no clear apprehension of these human distinctions. A venereal origin has been mentioned, but epidemic infestation may, and often does, result from a community water closet, as in office buildings. Inferior hotels or lodgings, where the cleanliness of the sheets is neglected, provide another source. Whether the lavatory accommodation in the public shelters lends itself to contamination or not I am unable to say, but since the pubic louse rather favours a class higher in the social scale than those using the shelters, on this ground it may be argued that epidemic pubic infestation is improbable. In any case, unless the individual is unusually hairy, delousing is easy, because, among other reasons, the insect soon dies when deprived of human companionship, in a matter of some forty hours. Treatment of the head and pubic louse is more concerned with general principles than with meticulous details. The selected parasiticide should be capable of killing the insects, and the potential insects in the nits, without risk to the human infestee. Paraffin oil, or carbolic lotion 1 : 40, satisfies these requirements : the subsequent toilet of the hair with a fine comb is a complementary and necessary addition. Shaving the pubic hair is probably an unnecessary measure against the crab louse, but, paradoxically, called for in many cases of body louse infestation.

Finally comes the consideration of the body louse, the sinister figure in this unpleasing trinity. In the case of the other varieties, the eggs are attached to the individual, to the hairs on the head, pubis, axilla, &c. The body louse has developed a different technique, it chooses the seams and crevices of the clothing for the precious eggs which are to provide a new generation, and since one female is capable of laying about 300 eggs, it will readily be appreciated how rapidly a pronounced degree of lousiness can develop. The insects are of an adventurous nature, and will leave the original host to seek new or perhaps more refreshing sustenance in another individual. Medical men are well aware of this habit of the insect, and some, more agreeable to the louse's taste than others, will relate the discovery, not infrequently made, of lice on their clothing after a long day in the casualty department. All lice are obligatory parasites, being entirely dependent on man's blood for their nourishment. The body louse can, however, live alone for some ten days, a fact disconcerting to the imaginative who picture the nooks and crannies in the bunks and platforms where the sleeping thousands of men and women take their nightly repose. We have then, it would seem, reason to anticipate the growing menace of infestation from the body louse without, as I shall venture to suggest, the probability

of a parallel increase in the other forms of pediculosis. Scabies will no doubt also increase, but for other reasons. If this view, based upon inferences which I have given or shall give, is substantially correct, then it follows that it is upon the body louse that our particular attention should be focused. What effects are likely to result from an increase in the verminous? Perhaps inconvenience rather than disease, and, therefore, of quite a different order from the ills likely to follow the introduction of the organisms of diphtheria, pneumonia or tuberculosis among an overcrowded shelter community. While one may hope that epidemics of typhus and relapsing fever are improbable, trench fever is a possibility, and pyodermia is at least to be expected. Prevention of pediculosis relies on two measures: prevention of the contamination of cleanly or relatively cleanly people, and the destruction of the eggs on garments, &c. For the first part to be effective we must, I suppose, rely upon voluntary and confidential notification by the individual to the local Public Health Authority, notices to this effect being posted in the shelters. A voluntary system is always abused, nevertheless enough would be gleaned to indicate foci of special infestation whereupon appropriate measures could be enforced. Disinfestation of bedding and clothing thus becomes an indispensable part of routine treatment; the local authority can be relied upon to do this, and in a manner very different from the improvisations of an army in the field. The mobile steam disinfector for clothing as used in France in the last war purveyed a most misleading sense of security. The contents were almost always packed too tightly into the container, consequently the garments in the centre harboured living and active lice, easily demonstrated and easily seen by anyone whose curiosity led him to investigate. The patient must also be treated: not so much for the few lice present on his body, which a bath will destroy, but to remove the ova attached to the hairs. Although more than forty years ago Allen Jamieson described ova from the body louse on the lanugo hairs, this lesson was forgotten until the last war, indeed until 1917, when H. Bouillard repeated the observation and noted the frequency of the eggs on the pubic hair nine times out of ten. In the latter situation they had been attributed to the crab louse: to H. W. Barber belongs the credit of exposing this mistake, by hatching out the eggs, thus demonstrating the variety from which they came. A technique had long been perfected in the Skin Hospital in France for treating a dozen men in a group with barium depilatory, mass destruction which just gave time for the hair of the first to be ready for removal with a paper-knife after the application of the depilatory to the twelfth had been completed. This simple procedure may not be convenient for civilian life, but mention of it serves to draw attention to disinfestation of the person as being as important as, and complementary to disinfestation of clothing and bedding. Shaving of the pubic area may even be called for, as already mentioned.

I shall conclude with some observations on scabies, based upon three points taken from Radcliffe Crocker's well-known textbook.

(1) *The disease,* he tells us, *is propagated by prolonged contact with infected people or objects; it is rare for ordinary contact, like shaking hands, to be a cause of contagion.* With this opinion dermatologists will agree. It means that, unlike pediculosis corporis, mere proximity does not spread scabies. Of this there was ample confirmation in the Skin Hospitals at Hardelot and Etaples during the last war. There scabies was never isolated: the patients were treated and housed with the other skin diseases. Nevertheless, cross-infection did not occur. Therefore, any increase in the number of cases should implicate something outside shelter life, possibly a venereal origin, or carelessness with clothing and bedding in family or communal surroundings.

(2) *The diagnosis of scabies may be very easy or very difficult.* Nothing has occurred since Crocker wrote these words to disturb their exactness. The secondary impetigo may prove especially confusing. It will be remembered that the impetigo of scabies tends to be grouped over the elbows, knees, and lower buttocks, whereas in pediculosis linear excoriations and impetigo occur on the shoulders, lumbar regions, and thighs, and by this variation in pattern a key is provided by which the two conditions can be differentiated. Nor should we forget the obvious, namely, that the discovery of the louse or its eggs is unequivocal evidence of its activities.

(3) *There are two evils to be avoided: treating the patient too little and treating him too much.* This admonition has a special significance to-day in relation to the rival parasiticides and the claims made for their peculiar merits. I have always favoured the classical three-day treatment with sulphur ointment, because I believe it cannot fail if all the details are exactly observed; nor is it liable to produce a dermatitis. Further, it

occupies seventy-two hours, a period corresponding to the interval between the laying and the hatching of the eggs, which means that eventually insects only, not insects and ova, are being attacked. The one-day treatment of scabies is no novelty: it has long been the traditional practice of the St. Louis Hospital in Paris, where the thorough preliminary soaping and bathing are essential parts of the ritual. The proportion of failures is considerable, no doubt in part attributable to the neglect to disinfect the bedding. In this country the Danish ointment was at one time a popular short cut, and recently a compound containing benzyl benzoate has been advocated. My criticism of a one-day treatment is that it may come within Crocker's third evil, that of treating the patient too little, and in this connexion it is a significant fact that the eggs take three days to hatch.

More than this I am not entitled to say, as I have not had sufficient experience of benzyl benzoate: others who are better qualified will give us the benefit of their views.

Dr. F. A. E. Silcock: I have been interested in Dr. Gray's reference to the fact that during the two years previous to the present war there was an increase in scabies. Could that not be accounted for by the sociological conditions in the distressed areas, due to overcrowding, or poor hygienic conditions? People went from these areas to London and other towns, in search of work, with the result that there was an increased rate of infestation. This was certainly true of my own city, Leicester, where we had many young fellows and girls from South Wales, Newcastle upon Tyne, and other areas, coming to learn a new trade or to go into domestic service. That fact might explain a good deal of the pre-war increase of scabies. At the beginning of the present war Leicester was considered "a safe area", and people were evacuated to it from many parts of the country (mainly from big industrial towns), with the result that scabies became, and still is, an absolute nightmare. Scabies used to be comparatively rare in out-patient clinics, but now it is common. Frequently a mother will come with two children, or with a baby, and all will be infected. She will say that several other members of the household, whom you do not see, have also got the same complaint.

Many cases of scabies, particularly in clean people or those who are frequently washing themselves, are not at all typical in the signs. I have mistaken many for other conditions, until I myself am beginning to acquire "scabies phobia" from seeing it so often. The best way to make sure of the diagnosis in these difficult cases is to find an Acarus and/or ova from one of the lesions. One atypical case was that of a woman who kept a high-class hairdressing saloon. In this work she was always washing her hands and forearms. These parts showed no signs of trouble, but there were suggestive lesions on the thighs, hips, and a few on the abdomen. When asked about her husband, she replied that he had an irritable rash on his fingers, wrists, &c., and this was confirmed by finding the Acarus in his lesions. A similar case was also seen by me recently, in which the woman kept her fingers and hands very clean and well manicured, and her forearms frequently washed. These parts again were clear, but the Acarus was found in her husband's lesions.

Dr. MacCormac mentioned the benzyl-benzoate treatment. All these treatments for scabies, however, either start with the vigorous application of soft soap and water, or the soft soap is combined in the prescription for the medicament used. (This is the case in the benzyl-benzoate treatment.) From my experience I believe that the soft soap and scrubbing is probably the main factor, and that the rest of the prescription does not much matter. This was accidentally demonstrated to me a few days ago, by the following incident. A well-marked case of scabies in an adult man was seen by my partner, Dr. F. S. Airey, and myself. He was given the usual prescription for benzyl benzoate and soft soap to take to his local country medical practitioner to have dispensed. The latter, never having heard of benzyl benzoate, did not bother to give him this, but only gave him the soft soap. The patient scrubbed himself with it and water for five days and nights—I had told him only three days. At the end of that time he was just as clear as anybody I have ever seen. The only thing was that he had scrubbed rather too hard and a little scaliness had resulted, which cleared in a day or two. Some people use soft soap, water, and a nail brush, and it seems to work as well as all the other prescriptions combined.

Dr. H. J. Craufurd-Benson: I had not intended to take part in this discussion, but at the President's request I will add a word or two to what Professor Buxton has said about the work on which Dr. McLeod and I were engaged. In working in rather a closed com-

munity in the East End of London, among the inhabitants of common lodging-houses and Salvation Army hostels, we found that the degree of lousiness of the men is to a considerable extent correlated with their personal hygiene. Those who have few lice are those who wash their shirts once a week; others with 30 to 50 lice change their undergarments when they think they will, and yet others are always lousy and do not care. This seems to indicate that public education might do a great deal towards preventing lousiness, though it would not entirely prevent it, because some of the individuals in this community who do all they can to prevent themselves from becoming lousy invariably harbour one or two lice.

Professor Buxton has mentioned the study of lice which are confined in small cells attached to the body. I myself am a member of a team working on parasitic diseases of animals, not humans. We have learned that the moment the parasite is confined, either to a small area on its host, or off its host, its reactions are liable to be misleading.

In this work on the louse we examined a wide series of insecticides, testing them on lice confined in little boxes of the type which Professor Buxton has described, but we found that an insecticide which would kill lice in the laboratory will not necessarily kill them when used on a verminous person. An insecticide may work successfully in the laboratory and be quite hopeless in the field.

Another thing brought out in this work was that if an insecticide affording good protective properties could be obtained and put on the body or the clothing, it would solve one's difficulty supposing one could not kill the louse eggs. I have often tried to kill the eggs of cattle lice and sheep lice and have found that effective agents are liable to cause dermatitis in the host. But if one uses an insecticide which will kill the adult louse or the louse in the young stage and that insecticide can be left there until all the eggs have hatched, then those newly-hatched lice will be killed by the insecticide.

Dr. H. W. Gordon: With regard to scabies, how long does the Acarus live when not in contact with the human body? I have never been convinced of the necessity of disinfecting clothes which are not constantly worn, and likewise bedding.

I have recently had one case where a patient appeared undoubtedly to be infected from bedding since she had taken the precaution of going to the hotel where the infection had occurred, with her own bed linen. In the same connexion, I have no doubt that everybody has come across what I might call latent cases where scabies has made its clinical appearance after a patient has been in hospital for some five or six weeks and no obvious source of contact can be found. If we rule out what must be the faintest possibility of a visitor affecting such patients, one can only suppose that the condition can remain dormant or latent, for a long time. In two such cases, patients were seriously ill and as their general condition improved, scabies became apparent.

I have found the benzyl-benzoate treatment satisfactory; I have seen two or three cases of acute dermatitis arise when sulphur has been used previously or subsequently to benzyl benzoate.

Dr. F. F. Hellier: Speakers have mentioned that scabies was on the increase before the war. I can quote Leeds figures in this connexion showing a percentage in 1934 of 2·1 among those attending the clinic, rising to 5·8% in 1938. I mentioned this in a paper read last year, and Professor Oppenheim of Vienna, who was present at the meeting, said that exactly the same thing had occurred in Vienna, and that it was obviously a European-wide occurrence. Professor Oppenheim attributed it to the greater impoverishment of living conditions in Vienna during those years, but in this country there was no impairment of living standards between 1934 and 1938, and yet the figures have almost trebled.

I do not think a sulphur-resistant Acarus has been found. Once scabies gets on the increase there is for everyone a greater chance of becoming infected unless some immunity develops. No personal immunity to scabies will develop until people learn to keep themselves free. I can only regard the increase as cyclic.

There is one little point with regard to treatment. If one advises an out-patient to have a hot bath for three nights he will answer "Yes" in the delightful way that out-patients have, but the following week it may be discovered that he had in fact no bath in his house. The practice at my hospital now is to refer every such case to the lady almoner, who has full details of the treatment. She will go into the whole question with the patient, including the question of contacts, and possibly arrange for the use of a neighbour's bath if the patient has none.

Lt.-Col. G. B. Mitchell-Heggs: I have had the opportunity of seeing these cases first of all from the point of view of a regimental medical officer, then as an officer in charge of a division of a hospital and finally as a dermatologist. A number of different points arise.

When the war started a number of doctors joined up who found themselves for the first time in khaki looking after men in the mass. Dermatology was a mystery to many of them. They were quite at sea when shown conditions common to all of us. They were unable to recognize a case of atypical scabies and unfamiliar with a method of obtaining the Acarus for microscopic diagnosis. In suspected pediculosis they were often searching for the pediculus and ignoring the nit on a hair.

The so-called latent case one meets with in a unit or ward is a real difficulty and I think it very unwise to pass a man as clear on the strength of a single examination. One must recognize an indefinite incubation period and realize that some men infested with pediculi complain of no itch.

I do not think that parasitic diseases can be quite the problem they were in the last war. One very sound Army practice is the weekly examination of troops, which has revealed many a latent or symptomless case. Compulsory examination of shelter cases would be an excellent plan if an increase in infestation became noticeable.

Dr. Gordon has raised the question as to how far disinfestation of clothing should be carried out; this is a real problem. I insist on the disinfestation of tunics because an Acarus may lurk in the sleeve cuff.

Dr. Louis Forman: I have been interested to hear that, in spite of the conditions under which many people have been living in shelters, pediculosis, including pediculosis capitis, has not increased in incidence. In a very small experience of examining children in shelters, I have been rather struck by the proportion showing pediculosis. They have not come up complaining of itching of the head, impetigo, or cervical adenitis but of other things, and I took the opportunity of looking at their heads. Although the number sampled could not be considered representative, I had the impression that pediculosis is common. The question should be settled by somebody examining all the children in one or other of the large shelters.

Dr. MacCormac's remarks on the infectivity of scabies are interesting. Some superintendents of hospitals regard scabies as being dangerous and infectious to the nursing staff.

In my experience at the out-patients' department with benzyl benzoate over a period of three years, it was found to be quite satisfactory, or at least as satisfactory as treatment with sulphur ointment, and there has been no greater liability to produce dermatitis.

Mr. A. Murray Stuart: Scabies in my district has increased very rapidly since air raids became intensified, owing, I think, to the greatly increased use of air-raid shelters. As I was not quite content with the usual sulphur ointment treatment and as benzyl benzoate was unobtainable, I have, for the past few months, been using 40% sodium thiosulphate lotion followed by 4% hydrochloric acid and have found this method to be successful. Nascent sulphur is generated on the skin surface. No case of sulphur dermatitis has as yet occurred. After hearing Dr. Silcock I am in some doubt as to whether the good results may not be largely due to the soft soap bath with which the treatment commences.

Dr. F. S. Airey: I suggest that the reason for this cyclical change in the incidence of scabies is not so much the factors which have been mentioned as the training of the individual practitioner. I am of the post-war generation so far as the last war is concerned, and during the last war many doctors became scabies-conscious, and remained so for some time after the war. Then followed a period during which scabies seemed to decrease, and many young practitioners who entered practice were unfamiliar with scabies. Due to this much scabies is now missed, and there appears to be an increased incidence in consequence. Now, when scabies is again on the increase, doctors are waking up to the condition. Under treatment scabies again appears to decrease. I suggest, but I may be wrong, that this may account for the cyclical variations.

The President (Major W. J. O'Donovan): Since I have been a member of this Section I have never listened to such a keen discussion on man's historic parasites! There is not a professional dermatologist amongst us who does not claim *ex professo* to speak on the question of scabies at any time or any place, and it is worth noting that many have been so continent this afternoon.

I had the privilege once of carrying out a post-mortem examination on a patient aged 18 who had died actually from pediculosis corporis. The cold, bitten, pallid body was a carapace of parasites. When the heart was opened a condition of early ulcerative endocarditis was found. The condition was due to lack of care on the part of the parents, the patient, and then of the authorities.

My next point is the singular continuance amongst us of scabies even in cleanly people: in spite of good community hygiene it does not disappear. It will be agreed by those who have listened closely to this discussion that the Army to-day is clean while the civil population threatens to become unclean. Soldiers frequently contract scabies on leave. Where I work now, in the centre of some 90,000 troops, I see over 300 skin cases a week, and there occur about 13 new cases of scabies and 15 cases of venereal disease amongst the cutaneous mass. Scabies, therefore, in the Army as I now see it, is a small matter. But I remember one village area from which there came over months a continual supply of scabies cases. Then, after an inspection by the sergeant-major—not by a medical officer—there came one heavily infested man with signs of scabies all over him, and the unchanging story that he had never itched. There are people who are scabies-carriers, heavily infested, who have never, in the lay sense of the word, suffered from scabies.

There was one extraordinary experience among miners. A new intake came to the camp, and among these there were a dozen, who, when they lifted their arms, showed their armpits to be black with pediculi.

On the question of treatment I would offer a caution. I had, recently, to handle a claim from a woman who sought damages from her doctor because his treatment, which included flowers of sulphur, had blackened her newly-painted bath!

The question of contagion through close and constant proximity to scabies is of great medico-legal importance. Those who wear garments which are also on occasion worn by other people, such as usherettes and porters, may be inclined to ascribe any trouble of this kind which befalls them to the garment. To establish a dubious claim the contact should have been undelayed and prolonged.

As to the disinfestation of clothing I had not done it for fifteen years until the war. In the Army I have seen no return cases, but it seems hard that a soldier should have his kit and blankets put into the hands of an anonymous hygiene employee, who proceeds at times to destroy them in the name of pure and applied science.

Among remedies let me mention the Marcusson ointment, invented by a pharmacist, but more mobile and easier to rub in than the historical sulphur ointment—not more effective, but more convenient.

The Sister at the St. Louis Hospital, Paris, cured scabies with sulphur ointment in one day, twenty years ago. She watched all the patients rub in the ointment until they perspired. The treatment of scabies needs supervision, for it must be continued, in effect, until perspiration does take place. In that event a one-day cure will be achieved, but not if it is left unsupervised to the orderlies.

Professor P. A. Buxton, in replying, said: "On the question of the spread of lice dermatologists have expressed very divergent views. The question of lice spreading in shelters is difficult. We have no information as to whether the head louse is spreading or not, and such information is difficult to obtain in view of the evacuation of school children; in peace-time we should have the evidence of school medical officers and nurses, but we cannot get information from them now. As to the body louse, work has been done in shelters by several people in different parts of London: they have spent evenings and nights in the poorer parts trying to find out by indirect methods, such as talking to shelter marshals and nurses in shelters, as well as to doctors who see a good many people stripped. At present we have no evidence that the body louse is increasing in London.

As to the detachment of nits from the hair, we know no way of doing it. Cannot we impress on the public that we are not hairdressers, and that while the question of looks and cosmetics may be important it does not matter from our point of view? Is it not sufficient if we can tell a person that there are no live nits or lice in the hair, and that that is all that interests us?

Dr. Gray and others pointed out that if people were hygienic in their habits, if they changed and washed their underclothing, there would be no body lice. But what is going to happen in a badly bombed area, in which perhaps many houses have no gas or other means of heating and only a small supply of water? Moreover, in times of peace better

ways of killing the louse and its eggs are very badly wanted, and the new agents which I mentioned will have their use then. A.L.63 is so convenient because it does not smell and does not make the hair wet, so that it can be used on the young woman with a permanent wave. She will not willingly have her hair wetted, but she might use a powder. The other agent has the vaulable property of killing the nits as well as the lice. If we are to get rid of the body louse it is no use instructing a person to go to a cleansing station, and we need something more convenient and more easily applied in the out-patient department. With these new insecticides we might get completely rid of the louse, perhaps within a few years.

The substances I have mentioned cannot at present be obtained commercially.

Section of Odontology

President—E. C. SPRAWSON, M.C., D.Sc., L.R.C.P., M.R.C.S., L.D.S.Eng.

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The Structure of the Bones of the Face in Relationship to Fracture and other Aspects of Facial Injuries

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and B. W. FICKLING, F.R.C.S., L.D.S.Eng.

WE are attempting an investigation into the changes occurring in the bones of the face as a result of injury, and have selected two particular features which seemed of sufficient interest for discussion. They are the relationship of fracture of bone to tooth sockets and some important factors in the arrangement and structure of the bones of the face.

We had come to the conclusion that the form of the facial and cranial bones is such that resistance to injury is a most significant feature. It is due to the distribution of density in the bones and the arrangement of curves, buttresses and tie-bars, of which the zygomatic arches, pterygoid processes and palate bones are examples. Thus a blow upon the front of the alveolar arch is widely disseminated through the zygomatic bones, the bones of the nose and the palate, in such a manner that no great force is transmitted directly to the cranium, and the vital centres escape injury.

The study of curves, stresses, elasticity and other important features are beyond the scope of this paper.

THE RELATIONSHIP OF FRACTURE OF THE JAWS TO THE TOOTH SOCKETS

Bone density and its arrangement presents a study in itself. It is well to remember that the matrix of compact and cancellous bone presents identical features under the microscope, the difference lying in the interstices, which in the one are small, and in the other large. A fracture passes along the line of least resistance, so that once the surface layer has yielded, it follows an irregular path through the cancellous bone, being diverted by the more resistant trabeculæ, thus accounting for the obliquity of many fractures. Elasticity also plays an important part in determining the path of the fracture line. There are many differences between the nature of the forces inflicting an injury but the dissemination resulting from the impact is similar. In the last war the majority of fractures resulted from missiles whilst in this war crushes and blows are at present more frequent. At the moment we are not so much concerned with the effect produced at the point of impact as with the resulting forces which are continued into the tissues until completely neutralized.

The strength of the tooth unit.—When examining a large number of radiographs of fractures of the bones of the face we were astonished to find that rarely did the line of fracture pass through a tooth socket. More careful examination revealed an unexpected conclusion, that the fracture always passed around the tooth socket, except in certain readily explained incidents. This observation caused us to analyse the factors determining the line of fracture. The cylindrical socket of dense bone is supported by the root of the tooth, having a firm elastic bed intervening with fibres passing into the bone

and the tooth. This provides a highly resistant unit which is further strengthened by bony struts to neighbouring units and to the superficial compact bone.

The great strength inherent in tubular construction and that resulting from angulation of a thin material is fully appreciated in architecture and engineering. A vertical section cut through the mandible and through the roots of the teeth, demonstrates the tubular

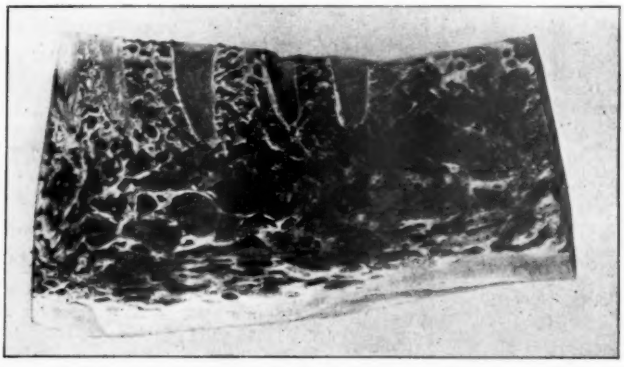

FIG. 1.—Vertical section of mandible to show conical form of the lamina dura, and the distribution of the larger intertrabecular spaces.

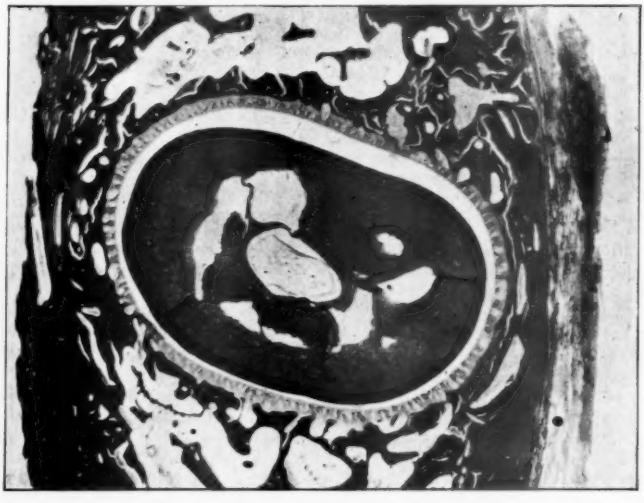

FIG. 2.—Histological preparation showing tooth, periodontal membrane, compact bone and cancellous spaces.

character of the compact bone forming the tooth sockets, well called the lamina dura (fig. 1). These tubes are in fact sections of a cone with the shape of the roots of the teeth. They are not just hollow cones of bone but as described, are units strengthened by the fibres of the periodontal membrane which have an intimate attachment to both

bone and tooth (fig. 2). This ligamentous attachment must be separated from the bone or the tooth over a wide area if the fracture is to pass through the tooth socket ; moreover, it is recognized generally that bone is more readily fractured than a ligament ruptured. The resistance to extraction of even conical-rooted teeth is evidence of the strength of the fibres of the periodontal membrane, for misapplied force will readily fracture the root without dividing the fibres. The weakness in the bone obviously lies below and between the units formed by the sockets, where the larger intertrabecular spaces occur, providing the explanation of the site of fracture below and between the teeth. Although both the mandible and maxillæ are affected in a similar manner, the mandible is more easily examined and radiographs are also more easily obtained, so that it is used for description in this discussion.

An analysis of the line of fracture in relation to teeth needs to be considered from both the positive and the negative aspects. As negative evidence may be cited the large number of severe injuries of the mandible in which the bone is comminuted in the region of the large medullary spaces without involving the adjacent sockets (fig. 3). Radio-

FIG. 3.—Gunshot wound of mandible, with separation of the lower dense margin. This severe comminution has not involved the tooth sockets, which should occur if they presented a line of weakness.

graphs were shown of severe injury of the body of the mandible involving the bone up to the apices of the teeth, which were free from injury—most highly improbable if the tooth and its socket were a source of weakness.

The positive evidence should be demonstrated from actual specimens. These are difficult to obtain, but the radiographic evidence is sufficiently conclusive, although careful study is necessary on account of the overlapping of fragments. Some cases show the actual line of fracture passing between the teeth. On occasion the tooth itself may seem to be involved, but an accurately placed film will show the presence of the compact layer

of the socket from which new bone formation can be seen in later radiographs (fig. 4). It must be remembered that if infection is not controlled this bone may be lost and the tooth exposed, but it should not occur if the fracture is correctly reduced and fixation effected at an early stage.

There are certain conditions in which fracture *can* occur through the tooth socket. It is seen when the blow is directed immediately upon the tooth and bone, the former being dislocated or broken and the latter fractured. Another group of particular interest occurs when the socket is incomplete or when a tooth is unerupted. The follicle of a developing tooth is attached to the bone by soft, immature tissue, while the great bulk of the crown of the tooth in its crypt leads to relative thinness of the body of the bone. In the case of the third molar these features are intensified, for it lies near a definitely

FIG. 4.—Healing of mandibular fracture. There is new bone formation on the anterior surface of the premolar tooth.

weak point in the bone, the junction of the body and the ramus of the mandible. Thus although a tooth may be involved in this area, the fracture is nearly always through a crypt and not through a fully developed socket.

Classification of mandibular fractures.—If our conclusions are correct fractures of the mandible will need to be re-classified. The lines of least resistance constitute the determining factors. Thus fractures most commonly occur :

(1) Obliquely through the mandible, near the angulation in the canine region, involving the incisor region in front or the premolar behind where the bone is thinner on account of the fossa for the sublingual gland.

The mental prominence and genial tubercles strengthen the symphysis so that fractures in this area tend to be *very* oblique, whilst behind the premolars strength is increased by the bulk of bone and the internal and external oblique lines.

(2) At the double angulation at the junction of body and ramus (fig. 5F) where the general structure changes from that of a long bone to that of a flat bone.

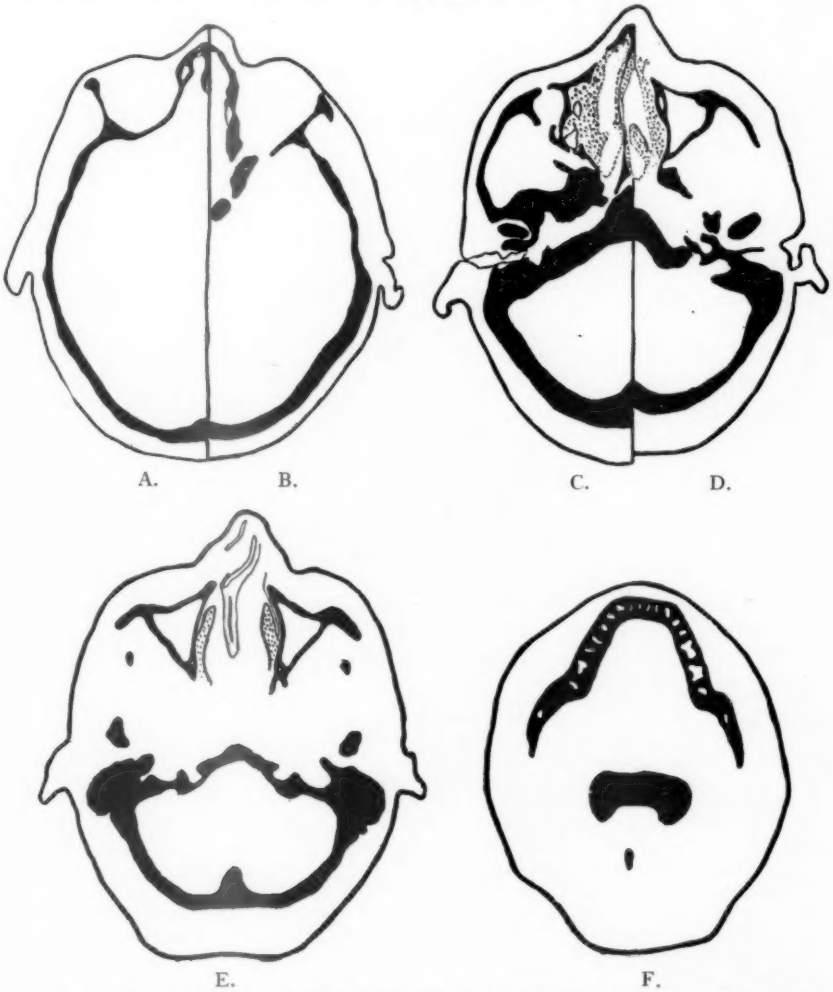

FIG. 5.—The attachment of the facial bones to the cranium. A series of horizontal sections of the head with the bone outlined. FIG. 5 C is cut at the level of Reid's base line. The remainder are parallel to this section. A. The upper third of the orbit. B. Level of optic foramen. D. Just below the orbit. E. About 4 mm. above anterior nasal spine of maxillæ. F. Mandible, level of the necks of the teeth, showing marked angulation. (Modified from Eycleshymer and Shoemaker.)

(3) As a result of indirect injury, along a line passing downwards and backwards from the sigmoid notch to the posterior border of the ramus, well below the condyle. On this account we have termed fractures in this area subcondylar as opposed to fracture of the neck of the condyle. The last occurs very rarely and then from direct injuries.

(4) Fracture of the coronoid process, usually due to a missile.

(5) Horizontal fractures in the line of the large intertrabecular spaces separating the alveolus with the tooth units from the body of the bone.

THE ARRANGEMENT OF THE BONES OF THE FACE AND THEIR RELATIONSHIP TO INJURY

The attachment of the facial bones to the cranium is of special interest in fractures for they may be regarded as suspended from the cranium by the processes of bone surrounding the orbits. An appreciation of the amount of bone at different levels is facilitated by sections cut in the horizontal plane. Tracings made from the anatomical atlas of Eycleshymer and Shoemaker (1911) forcibly impress one with the delicacy and attachment of the facial framework (fig. 5). The maxillæ, the largest bones of the face, carry the strong alveolar

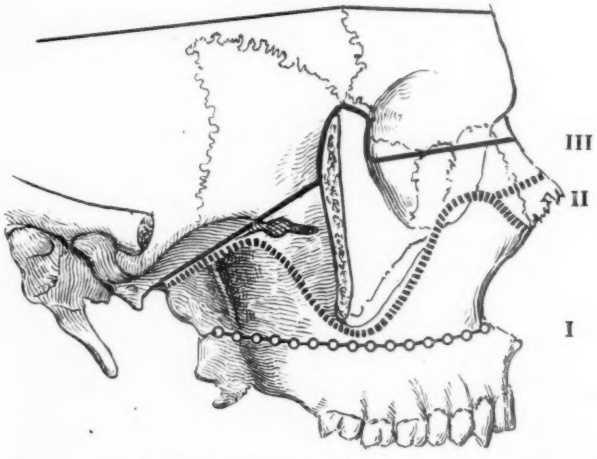

FIG. 6.—The common lines of fracture of the facial bones as defined by Le Fort. (Diagram upon figure modified from Quain.)

arch and the supporting dome of the palate. The upper part is hollowed by the antra and is related to the bones of the internal nose by numerous sinus cavities. The whole is built up of thin bony plates and cancellous bone making a light structure. Three fissures, the superior and inferior orbital and pterygo-maxillary present definite interruptions between the facial and cranial bones.

The processes connecting the face to the skull and for the protection of the eyes are of dense bone. They are so arranged that the vertical pressure of mastication is strongly opposed, but they possess less resistance to forces applied in other directions, which not infrequently produce fractures through the orbits. The body of the maxilla is weakest through the antral walls so that large or small fragments, with alveolus carrying teeth, may be produced; whilst at times the outer alveolar plate may be levered away by a direct blow upon the incisor teeth.

Fractures may pass from before backwards above the arch of the palate, also through the infra-orbital canal and the floor of the orbit, usually from lateral stress. Direct blows result in definite lesions and although missiles cause destruction at the point of impact, the disseminated stresses tend to follow the fracture lines of indirect injury.

The distribution of bone may appear to be feeble, but it is remarkable how efficiently the dense bone and the curvatures are arranged for dissipating applied forces and protecting the cranium and its contents.

Le Fort's experiments and classification.—Le Fort (1901), by nearly forty experiments

upon the cadaver, obtained detail which it is impossible to derive from clinical experience. Blows of several types were directed at various parts of the face and the resulting injuries determined by meticulous dissections carefully recorded. He was surprised at the degree of violence required to produce fracture. As a result of these experiments he defined three lines of weakness traversing the facial bones (fig. 6). For simplification, in the following descriptions the fracture line is only described on one side of the skull. It must be appreciated that combinations of the types of fracture occur.

The first and simplest fracture divides the maxilla above the alveolar process, traversing the wall of the nose and the canine fossa, passes beneath the zygomatic bone to the pterygomaxillary fissure, and may or may not divide the pterygoid processes (fig. 5E approx.). This is called Guérin's fracture or Le Fort I.

Le Fort II is a fracture at a higher level, through the upper part of the nose, inside and below the zygomatic bone. Starting at or just below the nasal bones, the fracture line crosses the nasal process of the maxilla and the inner wall and floor of the orbit to the region of the infra-orbital canal. It then cuts off the zygomatic process of the maxilla with the zygomatic bone, continues backwards to the pterygo-maxillary fissure and fractures the pterygoid process near the base. The nasal septum is also fractured (figs. 5C and D).

Le Fort III completely separates the face from the cranium. The line of the fracture crosses the nasal bones and the nasal process of the maxilla, the upper part of the inner wall of the orbit, opening the ethmoidal cells, to the neighbourhood of the optic foramen, which is not involved (figs. 5A and B). Reaching the back part of the sphenomaxillary fissure the fracture line bifurcates, the front arm crossing the outer wall of the orbit to separate the zygomatic from the frontal bone, while the posterior arm separates the pterygoid process near the base. Separation of the face is completed by fracture of the zygomatic arch, while the nasal septum fractures high up. This line of weakness has considerable value in protecting the cranium from blows upon the face. The cranium is rarely fractured, but if fracture does occur it is always from forces acting through the zygomatic bone. There is one exception, emphasized by Le Fort. When the upper part of the nasal bone is broken the cribriform plate is involved ; a feature of clinical significance.

These lines of weakness define the areas of greater resistance which form three main fragments, each or all of which may sustain secondary fractures. It is of interest that the most severe fractures of the face are produced by direct or indirect forces acting upon the zygomatic bone—whether from the front or the side.

Clinical significance.—Each of the two factors described has definite clinical importance. They cannot be fully discussed but certain points may be emphasized. As the fracture so rarely passes through the tooth socket extraction is contra-indicated, for it is likely to inflict further injury and favours infection by the breaking down of blood-clot and collection of debris in the space created. In addition firm fixation of the mandible is aided by retention of the tooth and allows the small quantities of compact bone over the root to undergo regeneration. Further the sanctity of the fracture hæmatoma is maintained.

With regard to the upper part of the face, a knowledge of the probable lines of fracture emphasizes the caution which should be exercised and indicates the stresses which should be avoided in treatment.

A number of these fractures pass unrecognized, for they are poorly revealed in radiographs and there may be little more than slight pain and tenderness.

We must make an apology for the incomplete nature of the paper. Among other causes the closure of the Royal College of Surgeons made it impossible to re-examine and demonstrate the excellent specimens in the war collection, while barrage and bombs at least caused inconvenience. The paper was illustrated by forty photographs and diagrams.

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Fractured Mandible—A Sign of and a Method of Treatment

By Frank Coleman, *M.C.*, L.R.C.P., M.R.C.S., L.D.S.Eng.

In 1913, I read a paper before the Eighteenth International Congress of Medicine in London (Stomatological Section) on The Treatment of Fractures of the Mandible. This paper was based upon some fifty patients or more, suffering from this injury, who had passed through my hands.

I wish to refer to two parts of this paper which may still be of value, one part concerning diagnosis and the other, treatment.

(1) *A Sign in the Diagnosis of Fracture of the Mandible*

This diagnostic sign had up to this time (i.e. 1913) escaped attention or had not been appreciated to the extent it deserved and even now does not appear in textbooks except by James and Fickling ("Injuries of the Jaws and Face", 1940), who mention extravasation of blood into the area to be described as a diagnostic sign of fracture of the mandible. The sign in question is produced by an effusion of blood into the tissues of the floor of the mouth, and gives rise to a very characteristic appearance of its mucous membrane, which becomes raised, forming a bluish, tense and elongated swelling under the side of the tongue. The sublingual fold lying between the tongue and the mandible is the part chiefly involved in this effusion, as the mucous membrane elsewhere (i.e. alveolus and tongue) is too firmly bound down to bulge in this manner (fig. 1).

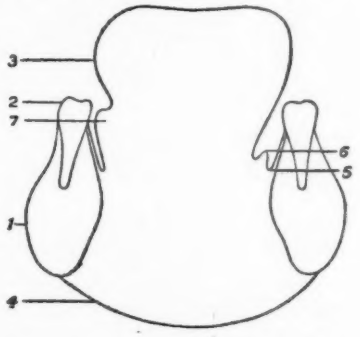

Fig. 1.—Coronal section through mandible and tongue in premolar region, showing: (1) Body of mandible; (2) premolar tooth; (3) tongue; (4) deep cervical fascia; (5) reflection of mucous membrane from gum to tongue; (6) sublingual fold (normal condition); (7) sublingual fold distended with effused blood, forming the characteristic swelling beneath tongue.

This sign alone will serve to differentiate an external bruise from an injury which has produced in addition a disunion of the jaw, and it would be difficult to understand from an anatomical point of view, how an effusion of blood could take place into this space, bounded externally by the deep cervical fascia and the body of the mandible, unless a lesion of one of these structures has occurred. We can disregard the deep cervical fascia, which is a structure not readily torn, and therefore surmise that the breach has involved the body of the mandible.

I have found this sign, which appears within an hour or two of the injury, to be almost invariably present and to form as conclusive evidence of a fracture of the mandible as an effusion of blood into the orbital cellular tissue is evidence of a fractured base, and for similar anatomical reasons.

Swelling in the region of the fracture as mentioned in most books is too indefinite and does not describe the characteristic appearance, apart from which the swelling, like that associated with a fractured base (anterior fossa) is not in the immediate vicinity of the fracture.

(2) *A Clamp for the Treatment of Fracture of the Mandible*

In 1909, I devised a clamp for fixing the fragments of a broken jaw. The principle consisted of a strong steel spring which could be opened to enclose the fractured ends of the bone and when released embedded itself in the mucous membrane and bone by means of its projecting claws. The clamp was applied as follows:—

The patient was placed under an anæsthetic, the fragments of the jaw were reduced, the clamp was opened (with a special instrument) and forced over the jaw in the region of the fracture and then released; thus leaving the clamp embedded on each side of

FIG. 2.—Showing method of applying clamp to the jaw.
[The clamp and clamp forceps were made by Messrs. C. Ash, Sons & Co., England.]

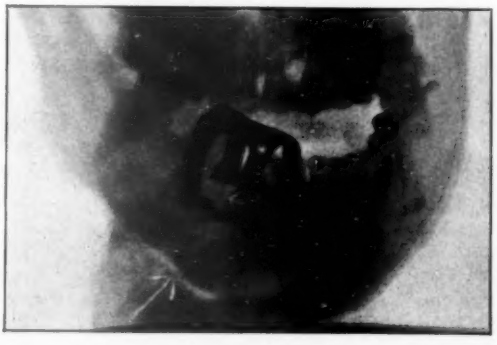

FIG. 3.—Radiograph showing the jaw-clamp in situ. The arrows indicate position of fracture.

the fracture (fig. 2). The sharp projections or claws at the extremities of the limbs of the clamp readily penetrated the mucous membrane and underlying bone. The ease with which the clamp could be inserted and removed, its cleanliness, and the ready access to the site of the fracture that it afforded, were advantages which appealed strongly in its favour; besides which the clamp was adaptable whether teeth were present or not, and could be used over and over again.

The result in the first case was excellent, but it is difficult to say how much this was due to its employment, as the result in most cases of fracture of the jaw is satisfactory (whether treated or otherwise) provided there be no great tendency to displacement of the fragments. The clamp was left on the jaw for six weeks, during which time the patient experienced but little discomfort.

The second case formed a good test as to the efficiency of this device in retaining the fragments in position (fig. 3), for there was much displacement (the posterior fragment over-riding the anterior), which, even under chloroform anæsthesia, required a large amount of force for its correction.

The clamp has been modified in two respects since last employed ; it has been made a little more powerful and the horizontal limbs carrying the loop or eyelet raised to facilitate introduction and removal. To-day the clamp might be constructed of stainless steel. A selection of four sizes would be required for differences in height (i.e. whether teeth present or edentulous) and differences in width of jaw. The operator must hold himself responsible for the removal of the clamp, as in the absence of the special clamp forceps, there might be difficulty in its removal.

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Section of Orthopædics

President—S. L. HIGGS, F.R.C.S.

[*November* 30, 1940]

MEETING HELD AT AN EMERGENCY HOSPITAL

The Functional Treatment of Congenital Dislocation of the Hip-joint

By FELIX BAUER

Formerly Orthopædic Physician of the Municipal Children's Hospitals of Vienna

CONGENITAL dislocation of the hip appears to be more common in Austria than in this country, and many cases have come under our care.

At first, the treatment advocated by Lorenz was carried out, but a study of the after-results of cases treated by this method prompted us to adopt the functional treatment for congenital hip dislocation. Lorenz and his school, although they made a diagnosis of this condition in the first year of life, did not advocate starting plaster treatment until after the first year on account of the adverse effect of plaster on the newly born. The disadvantage of all fixation methods is that great stiffness follows prolonged immobilization in plaster, and a joint which is not functioning fails to develop. The stiffness is due to the contracture of the capsular ligaments and muscles. Normal development of the hip depends upon the presence of the head of the femur in the correct position and function of that hip with free abduction. Although the immediate results of a case treated by the Lorenz method may appear to be good, a marked degree of secondary complications and poor results will be manifested if the cases are followed up for ten to twenty years.

Before describing the new functional treatment, I would like to put before you the results of my examinations of the newly born. The second month of life is the best time at which to examine for the condition of under-development of the hip-joint. In Vienna the pædiatricians have been aware of the importance of examining infants of this age. Under-development of a hip can be recognized and treated, and the evil effects of a shallow hip-joint prevented. Many cases of osteo-arthritis occur in young people and in those between the ages of 20 and 30. Often the cause of this idiopathic osteo-arthritis is a shallow hip-joint which, being mechanically unsound, is therefore sooner or later bound to develop osteo-arthritis. If these cases had been seen and treated in the second month of life, the hip would have developed normally and this untreatable condition would have been avoided. It is even probable that other conditions, such as Perthes' disease and adolescent coxa vara, are more liable to occur in those cases where the hip-joint is under-

developed. The early examination of infants is a useful addition to our system of infant welfare and would certainly lead to the diminution of hip complaints in later life.

During our investigations of infants, we have found a considerable number of cases which showed a condition of adduction contracture, i.e. limitation of abduction of one or both hips. Examination of the child revealed diminished power of abduction and it was noticed that the child moved one hip less spontaneously than the other, and would frequently lie only on the unaffected side. An X-ray in such a case would show abnormality of the hip. For instance, the socket of one joint will be shallower than that of the other and the ossification centre of the head of the femur on that side will be less far advanced than that on the other. Epiphyseal delay on one side is a danger signal. If treatment is commenced immediately and the adduction contracture is overcome, by ensuring free and unrestricted movement of both hip-joints, the difference between the two hips will become less marked and after several months, or perhaps years, both hips will be equally developed. Should the contracture persist and no treatment be given, the difference between the two joints will increase and in severe cases the development of subluxation, or even dislocation, will be seen in the X-rays during the first six months of life. In my opinion, only a very small percentage of dislocations of the hip are present at birth. The dislocation usually occurs during the first few months of life and is the outcome of a marked degree of adduction contracture of the hip, together with under-development and late appearance of the femoral epiphysis.

These observations have proved to me that there are two factors necessary for the normal development of a hip-joint, firstly, a position of abduction, and secondly, function. The Lorenz method of treatment by fixation in plaster prevents movements, and functional use is all-important in the life and development of a hip. The power of the head of the femur to create for itself an acetabulum is proved by the very striking fact that in cases of unreduced congenital dislocation where the child has not been treated and allowed to move freely, a false acetabulum appears on the dorsum ilii, sometimes of surprising depth.

My method of treatment is as follows: The hip-joint is reduced in a position of full flexion, and the reduction is confirmed by X-rays. The reduction is done as gently as possible to avoid damage to the epiphyseal region of the head. The femoral head is lifted forwards into the acetabulum from the back by a rotational movement. After reduction, the position of full flexion and abduction is maintained by means of a brace. If the case is seen early and the reduction appears stable, small active movements are begun as soon as possible. The patient is allowed to move in the brace and to crawl on the ground with the hips in a strongly abducted position. The duration of this frog-like position depends upon the growth of the socket, as shown by X-rays taken at intervals. The earliest case so treated was 6 months old; the average age was 1 year, though there were many of 2½ years of age. The oldest case treated was aged 5 years.

As the socket develops, the abduction may be diminished to a position of 90 degrees and gradually later to a semi-abducted position of 45 degrees. During this period the child is to be helped by suitable supports to learn to walk with the hips in an abducted position. On an average, the treatment takes five to eight months, but in cases seen later, in the second, third or fourth years, the treatment may have to be continued for months, or even years, until the head has the correct concentric position in the socket and the hip has grown sufficiently to render the joint stable.

The brace.—In the first six months of life, a little abduction brace can be made by the mother from cotton webbing (*Lancet*, 1936 (i), 1057). For cases over one year old, a stouter brace is made from leather and an abduction stick is placed between the knees to secure the correct degree of abduction. If the child is older, the brace must be stronger still. The braces made in England, after my design, have been manufactured by Messrs. Masters & Co., Colston Street, Bristol. It is advisable to have two braces, so that the child can be bathed in one and changed to the other afterwards.

The X-ray results amply justify this method of treatment. The quick development of the joint during treatment is quite different from anything which can be obtained with the Lorenz method. Unlike this, my treatment cures not only a dislocation of the hip, but also its cause, i.e. flat hip-joint. The results prove that it is more efficient in preventing further redislocation, or a wandering acetabulum, because the development of the correct socket prevents this. It is Nature's treatment and can be carried out for years, if necessary, without interfering with the health of the child. There is no damage to the joint, bones

or muscles. With function, the bones do not atrophy and muscles do not waste. The mental condition of the child more closely resembles that of a normal child. Nursing is much easier and the treatment is cheaper and needs no prolonged hospitalization. It is important that a child should be with his mother during the first years of his life and it has often been said that a bad home is better than the best institution. In uncomplicated cases, the child need remain only one week in hospital.

In later life, this treatment is also of advantage but the same degree of excelience in results cannot be expected with older children. Ideally, treatment must be carried out in the first months of life. Prevention is better than cure. As I have already pointed out, the earliest diagnosis is essential and treatment should be commenced before dislocation has occurred.

I have to thank Mr. Hey Groves for giving me the opportunity to carry out my treatment in the Bristol Hospitals in conjunction with, and under the control of his pupils, Mr. Pridie and Mr. Eyre Brook.

Discussion.—Mr. H. A. T. FAIRBANK said that it was now generally agreed that in infants a minimum of treatment was sufficient to effect a cure. Maintenance of simple abduction was sufficient: it was not a question of reduction, but only of abducting the leg so that the femoral head became central instead of excentric in the acetabulum. Dr. Bauer had been hardly fair to Lorenz, since the latter insisted on functional use of the limb while in plaster. He (the speaker) always encouraged his cases to walk after the first month in plaster, even the bilateral cases. He disliked the tendency in recent years to include the knee in the plaster since this interfered with walking and checked all rotatory movements of the hip. In cases beyond infancy he felt Dr. Bauer's method did not maintain sufficient abduction, the hip tending to be in not more than 70 degrees of flexion and 70 degrees abduction, whereas he thought a minimum of 90 degrees of both abduction and flexion was essential. He regarded complete reduction without force as an impossibility. Experience enabled the surgeon to reduce the necessary force considerably, but could never eliminate it.

Mr. J. C. SCOTT referred to a method used for congenital dislocation of the hip at the Wingfield-Morris Orthopædic Hospital, reduction being brought about gradually by traction in association with increasing abduction on a special frame. The value of arthrograms in determining the shape of the acetabulum was also emphasized.

Mr. T. T. STAMM compared Dr. Bauer's method of maintaining reduction with Batchelor's; in this method, the knees, but not the hips, are included in plasters which are united by a strut.

In reply to Mr. Fairbank, Dr. BAUER stated that Lorenz's insistence had been chiefly on fixation without scope for functional activity.

Mr. KENNETH H. PRIDIE stated that six cases had been treated by Dr. Bauer's method in Bristol by himself and Mr. Eyre Brook. The ages of the children were respectively 19 months, 18 months, 18 months, 2 years, 5 years and 5½ years. The cases had been observed over a relatively short time only, the longest period being nine months after commencement of treatment, but they showed, he said, great ease and comfort for the children during treatment. The children seemed happier than those treated by plaster fixation.

The chief advantage of Dr. Bauer's method, continued Mr. Pridie, was the short period of hospitalization necessary. Although the first one or two cases had been kept in hospital for several months for observation purposes, later cases were in hospital for only a week or ten days and later attended as out-patients.

Each case had at the end of the period of treatment shown stability of the hip and the child was walking well. Development of the acetabulum appeared to be progressing normally, and at a much greater rate than by the plaster method of treatment.

DISCUSSION ON THE CLOSED PLASTER TREATMENT OF WOUNDS IN THE LIGHT OF RECENT EXPERIENCE

Mr. S. L. Higgs: It was with incredulity, mingled with horror, that, some years ago, in the Barnes Hall of the R.S.M., a number of us heard Dr. Winnett Orr describe his method of treating osteomyelitis by opening up the infected area to afford drainage, packing the wound lightly with vaseline gauze and then locking up the limb in a closed plaster of Paris case. However, his results were impressive and it was not long before orthopædic surgeons tried this method for themselves and found it good.

The method was afterwards extended to the treatment of compound fractures, whether infected or not, and of other wounds of the limbs. It was not, however, until the fighting in Spain that the Winnett Orr technique was applied to war wounds and the remarkable results reported by Dr. Trueta appeared to afford ample proof of the value of this method.

In the hospital wards during the last war there were rows of soldiers with shattered limbs, imperfectly immobilized, and wounds pouring with pus which were subjected to daily or twice daily dressings, often under anæsthesia. Bone necrosis, sequestra formation and sinuses were the rule, and delayed or non-union of broken bones was very common. Throughout treatment patients suffered pain and, usually, continued toxæmia.

The contrast between this unhappy picture and the one presented by the wards of this hospital last summer is indeed striking. For instance, most of the men with severe arm wounds fixed in shoulder spicas were soon free from pain and fever and able to go out in the grounds in the sun, where they amused themselves by playing games such as single-handed croquet. The closed plaster method represents a notable advance in treatment and one cannot agree with the writer of a recently published book on war injuries, who considers this method to be still on its trial.

I have surveyed the results of 44 consecutive cases under my care. Most of them were wounded soldiers, who arrived after the evacuation of our troops from France. The majority were received into hospital five days after being wounded, still in their uniforms. Their wounds were covered only by a first field dressing, nearly all were heavily infected and some were full of maggots. It was too late for wound excision and all that could be done was to cut away sloughs and dead tissues, remove metallic foreign bodies with the aid of portable X-rays, and afford ample drainage by means of free incisions. The wounds were lightly packed with vaseline gauze and closed unpadded plasters applied in the usual way. Although in some cases great anxiety was felt, in only one instance was it necessary to remove the plaster before the appointed time, and that was for a secondary hæmorrhage from the circumflex artery.

I have made a rough list of some of the merits of this form of treatment and, also, of its disadvantages.

Merits:

(1) Fixation relieves pain and toxæmia and secures immobilization of the broken limb, at the same time allowing mobility of the patient.

(2) The poultice of pus and absence of interference seem to stimulate the growth of granulation tissue in a most remarkable manner. On removing a plaster case, say at the end of a month, I have found that even a very large cavity, due to the loss of the soft tissues, has almost filled with highly vascular granulations. These often spread over the skin edges and need curetting away.

(3) Owing to the rapid covering of broken bones, necrosis and sinus formation were most exceptional. In consequence of this, bony union often occurred in minimal time and, on more than one occasion, I was caught napping. Having moulded a fractured humerus which was in fragments into reasonably good shape—intending later on to carry out further adjustments—I found, at the end of about five weeks, that the bone had united firmly and the opportunity of improving the alignment had been lost. In only two cases has non-union persisted, and in both large gaps in the bones were present.

(4) Associated nerve lesions were common. Owing to the rapid healing of the soft parts and union of the fracture it was possible to carry out nerve sutures at an earlier date than in the last war.

(5) Infected joints still present a difficult problem, but I have in mind two cases, in each of which the lower end of the femur was shattered and the knee-joint involved. The men were extremely ill and amputation was contemplated. The application of closed plasters, with rubber tubes into each side of the knee-joint protruding through the plaster, immediately brought about a change for the better. To facilitate drainage, each day the patients were turned on to their faces. Now they are both walking again, one with a stiff knee and the other with a small range of movement. At any rate, their legs have been saved.

Defects :

(1) Complications due to *errors of technique* may occur. I have come across three disasters. In one case, on removing a plaster on the patient's arrival in hospital, I found a leg gangrenous from pressure, and amputation was necessary. In a second case all the toes had undergone dry gangrene. In a third—the case of a small boy who was an air-raid casualty—gangrene of the arm set in after closed plaster treatment and the arm had to be amputated.

I quote these cases not as criticism of the method but only as instances of its bad application and improper after-care. The surgeon must be familiar with plaster of Paris technique and the complaint of pain, prominent in all these cases, must not be disregarded. Furthermore, it is quite clear that trouble will occur if drainage on to the skin is not adequate.

(2) *Difficulty in maintaining extension* is experienced. This, of course, applies principally to the lower limb. Where extension has been really necessary I have deferred the application of a closed plaster until the fracture has been well on the way to union.

(3) A serious disadvantage is the *smell*, which has earned the description of "stink plasters" for this method. This, of course, was less noticeable in the summer time, when the men could spend most of the day out of doors and windows could be kept open. Now, however, in wards which are overcrowded and, because of black-out difficulties, ill-ventilated, the trouble is a very real one.

I have tried introducing a thick layer of BIPP, spread on a piece of gauze, over the wound with the paste outwards in contact with the plaster. For those who do not mind the smell of iodoform this has proved of value. Eucalyptus oil on gauze and, also, mercurochrome in solution in the water used for soaking the plaster bandages do undoubtedly reduce the odour. Neither of these expedients, however, proves effective when the plaster has been on for a week or two.

We found deodorizing bags most successful in preventing the escape of the smell. It is, of course, a serious disadvantage to envelop the limb completely, as it means, in an arm injury for instance, that the hand can neither be inspected nor used freely by the patient. There is no doubt, however, that this is the nearest approach to a successful deodorizing method up to date and it should be possible to improve it still further.

(4) Wounds treated in closed plasters *suppurate* and remain messy until the plasters are finally discarded. The skin around the wound is then found to be rimmed with inspissated pus which is firmly adherent, has the consistency of india-rubber and exudes a peculiarly pungent and unpleasant smell.

(5) In some cases the surrounding skin exhibits a *septic dermatitis* which is most irritating to the patient. Painting the skin with gentian violet seems to be of some benefit. In a few instances, where the dermatitis persisted after removal of the plaster, X-ray treatment was found effective.

(6) Lastly—I have left this to the end although it is perhaps one of the chief defects of the method—the *quality of the skin* which grows over the healing wound beneath the plaster *is poor*. It is often ridged and thickened, almost resembling a keloid scar, and frequently raw areas are apparent, due to autodigestion of the new epithelium.

For this reason I have sought the help of the Plastic Department and, when the fracture has united and granulations have replaced the lost soft tissues, I have asked Mr. Mowlem to deal with the problem of the skin. He has been able to clear up the infection quickly, showing that it no longer has a very strong hold on the wound. Often within a few days he has been able to apply skin grafts to the raw area.

Mr. E. T. C. Spooner : Systematic examinations of the bacteriology of these cases was not begun until early July, when they had been in hospital for four to six weeks. Nevertheless, certain observations are worth reporting.

As might be expected, the bacterial flora inside the plasters was very rich. Sometimes the thick brown partly inspissated pus seemed to be entirely composed of bacteria, so that a Gram-stained film of it might appear blue to the naked eye on account of the numbers of Gram-positive bacteria present. Of 29 cases examined, 20 were infected with hæmolytic streptococci, 20 with staphylococci, 19 with diphtheroid bacilli, 7 with Proteus, 8 with *Ps. pyocyanea*, and 2 yielded *Cl. welchii*. Some other bacteria were found, including anaerobic spore-bearing bacilli.

There is no indication that these bacteria were doing the patients much harm, except that those infected with hæmolytic streptococci were rather worse off than those not so infected. The surgeons in charge of the 29 cases were able to classify them into groups according as they were very ill, suffered from fairly persistent pyrexia, or periodic pyrexia, or were throughout their treatment apparently very well. Of the 17 cases falling into the first three groups, 14 were infected with hæmolytic streptococci ; whereas, of the 12 patients who were throughout very well, 6 only were so infected. These figures, and the difference between the two series, are not, of course, big enough to establish anything ; but they are suggestive. They do not take into account three patients, all infected with hæmolytic streptococci, whose limbs had to be amputated before my investigations began.

An important point about the plaster treatment is that enclosure of a wound in plaster does not necessarily protect it against cross infection with bacteria from other cases. Of 15 cases examined more than once, 8 acquired fresh bacterial species while under observation, three of the 8 acquiring hæmolytic streptococci. There is no evidence as to whether cross infection of this kind is acquired actually through the plaster, or on those occasions when the plaster is taken off and changed. The latter seems the more probable ; there is certainly ample opportunity for cross infection to occur when plasters are changed.

Whether bacteria can pass through a plaster from without inwards or not, it seems clear that they can travel in the reverse direction, coming from the inside of the plaster out on to its surface. Hæmolytic streptococci have frequently been obtained from the outer surface of a plaster, and shown to belong to the same agglutinative type as those present inside the plaster. This point is of importance, inasmuch as plaster cases constitute a hazard to other wounded patients in their neighbourhood.

Dr. J. Trueta said that he was glad to hear of the British experience, which confirmed the results he obtained in Catalonia during the Spanish War. In Barcelona the treatment was applied more quickly, the cases being sent to the hospital direct from the scene of the injury, whereas the majority of the cases just described had been of soldiers who had arrived in hospital several days after their wounds had been inflicted. If, in spite of this, both lives and limbs were saved this proved the treatment to be of great value. The majority of complications are due to technical errors, mainly insufficient excision of the damaged tissues and incomplete drainage. The only cases of compound fractures in which delay in the application of the plaster is justified are those in which there is doubt about the adequacy of the circulation, either in the limb distal to the injury or in the tissues immediately surrounding the wound. In practice it is in the thigh only that these conditions are met. In his experience dermatitis did occur with the closed plaster treatment but was never a serious complication. The practice he adopted in such cases was to leave the wound free and exposed to the air for a few days after the removal of one plaster and before applying the new plaster.

Mr. Rainsford Mowlem considered that Colebrook's demonstration of the elimination of hæmolytic streptococci from most wounds after two days of intensive sulphonamide treatment gave much promise.

Mr. J. C. Scott, referring briefly to bacteriological investigation of wounds undertaken with Professor Gardner, described the technique of inserting small Perspex windows in the plasters to obtain specimens at regular intervals. He pointed out that only a small number of cases had been investigated because only those cases that were seen early and could be followed throughout the whole course of their treatment were accepted.

Lieut.-Colonel R. Brooke stated that under active service conditions in France it was found impossible to carry out the Trueta technique. The war was one of movement, and it became necessary to evacuate casualties from the Base Hospitals with extreme rapidity. At first attempts were made to immobilize compound fractures in plaster, but as these cases could not be watched even for forty-eight hours it was necessary to split the plasters in case of subsequent swelling. Within the first two days the wounded had usually to face a long journey by ambulance train or motor ambulance, transfer to a hospital ship, and then a second journey by train.

Large plaster hip and shoulder spicas were cumbersome and not very satisfactory, and were gradually abandoned in favour of the Thomas's splint, in the case of leg wounds, which was found to be much more satisfactory and easier to manage than the Braun's frame. For fixation of the upper extremity, the arm was bound tightly to the side and no splint other than a posterior plaster slab was used. A simple flavine pack, applied after preliminary treatment with sulphonamide powder, was usually preferred to vaseline, which is messy and has little special virtue. The flavine pack is left in situ and the outer dressings only are renewed from time to time, usually about every four days.

The Treatment of Burns

By Rainsford Mowlem, F.R.C.S.

Now that we are coming to apply principles based upon civilian injuries to the type of burn caused by war, we are disappointed to find that the results of tannic acid treatment are sometimes indifferent and sometimes disastrous. In addition, improved methods in the treatment of shock are saving more lives and thus presenting us with cases of burns of an area and degree not previously encountered.

Primary shock does not appear to occur very frequently, but when it does it is comparable to the immediate shock following any other type of injury. In its train comes

Secondary shock, the onset of which varies from a few minutes to six to eight hours after the receipt of the burn. This phase is characterized by marked changes in the blood. These are chiefly a lowering of the serum protein and an increase in the hæmoglobin concentration. The cause of this condition is probably plasma loss, which may not necessarily be external. The treatment is the replacement of the lost protein.

Toxæmia is the third phase in the systemic disturbance. This is characterized by pyrexia, mental disturbance, sometimes vomiting and albuminuria, and progressive circulatory failure. The chief pathological characteristic is evidence of necrosis of the liver cells, and the blood changes which occurred in phase 2 tend to persist. The cause of this condition is far from clear, but may be associated with the absorption of tissue products which have been broken down by bacterial action. It appears improbable that this is the whole story, because the condition occurs in some burns which are not associated with any measurable degree of bacterial infection. Treatment is extremely difficult, but transfusion with fresh blood, and the institution of a high carbohydrate diet appear to be the most promising lines.

There is a fourth phase, **sepsis,** which, since Colebrook's work on sulphonamides, should never be allowed to develop.

Local treatment should be directed towards : (i) The early separation of all damaged tissues. There is no royal road to this end. Foments, saline packs or baths, hydrogen peroxide and even surgical intervention have their uses. Possibly trypsin may be useful, and work is being done on this point. When all the destroyed tissue is removed a protective layer of granulation tissue is formed and the general condition slowly improves. Complete recovery will seldom be obtained until this raw area is epithelialized if it is of any extent.

(ii) Infection must be avoided or controlled. Colebrook's work with powdered sulphonamide seems to have relegated the use of antiseptics, and such adjuvants as ultra-violet radiation, to a secondary place.

Burns fall into two separate categories :—

(1) Burns of chiefly first degree, with, say, a few patches of second degree destruction. The area involved may well be sufficient to cause serious general symptoms, but this does not alter the fact that the whole thickness of the skin is not destroyed and is capable, therefore, of local regeneration. Treatment must be directed towards three main points :—

(*a*) *The avoidance of further tissue damage ;*
(*b*) *The avoidance or control of infection ;*
(*c*) *The encouragement of the growth of new epithelium.*

It is this type of case which has given tannic acid its firm adherents, and indeed, this is the very case upon which so much work was done with tannic acid in civilian life. It is, in fact, the extensive scald. It is also true that for some patients in this class tannic acid does extremely well. It is applied after surgical cleansing by any of the many different methods advocated. It may be applied with any of the dyes, either singly or in combination. In that the method of coagulation relieves the patient, the nurse and the surgeon from the necessity of further treatment, it is good. In that it may control further plasma loss by external transudation it may be very good, but it must be remembered that the three desiderata stated above are worth consideration.

(*a*) *The avoidance of further damage.*—Firstly, surgical cleansing may entail the use of such precipitants as ether or spirit. Does this not inflict further destruction ? The mere use of tannic acid is dependent upon its coagulating effect. There is no certainty that only burned cells are included in this process and it must also be remembered that all of the dyes are fixative agents.

(*b*) *The avoidance of further infection* may well be obtained by a coagulum provided it is applied to a sterile surface, and also provided it neither crosses a body flexure, nor lies close to any body orifice. None of these points may appear important by itself, but if infection does occur beneath the coagulum the resultant difficulties and the resultant destruction may be very great. It cannot be soaked off and, as a rule, it must be cut off unless one is content with inadequate drainage. Either way more epithelial damage may be occasioned.

(*c*) *The encouragement of new growth* might be assumed to occur most readily beneath an undisturbed tan. Much comparative work, however, leads me to believe that not only is the healing process slower, but the resultant scar is of poorer texture and somewhat more vascular than that obtained by open methods. Much experimental work has also proved that all the dyes retard tissue regeneration.

In spite of these disadvantages tanning may be used if only on account of its simplicity in certain special instances. The indications would appear to be that the burn shall not be so severe as to prevent local regeneration, and that it shall not be across body flexures or near orifices. The one great additional exception is the hands, which will be dealt with later. My greatest difficulty is to make the necessary early decision as to the degree of the burn. I find it almost impossible to distinguish between partial and complete skin destruction until some days have elapsed.

(2) In this category come all those burns in which the destruction has involved the whole thickness of the skin (third degree), so that regeneration can occur only from the margins. If the area is small secondary healing may not take long, and will give a reasonable scar. On the other hand, an extensive area can never be expected to heal, to give a stable scar without contracture or dysfunction. The problem, then, is not only that of a burn, but also that of an extensive skin loss, and treatment should be directed towards the earliest possible surgical replacement of the lost skin. With every week that passes before grafting is undertaken, fibrosis increases and joint function may be disturbed.

In these cases the only possible indication for tannic acid would be the endeavour to control tissue fluid loss. It may therefore be a life-saving measure or, rather, it may postpone death, for in these cases cleansing under general anæsthesia cannot result in the removal of all damaged tissues, and the tendency for tan to become infected is relatively greater. In addition, any coagulum depends for its ultimate separation upon desquamation. If there is no underlying epithelium to regenerate and desquamate, then only the knife or sepsis will remove the tan. If the knife, one is confronted with almost

the same raw area at the end of, say, four to six weeks as was present in the beginning. If sepsis intervenes, fibrosis is increased. One might take one's courage in both hands and excise and graft the burn in the first instance, and I am sure that if this is feasible it should be done. It can be done with electrical burns, but the difficulty with heat burns is our inability to decide upon the extent and the depth of the burn. If excision is impossible, then it must be made possible at the earliest moment. In the case of an extensive skin loss due to accident, no one would dream of utilizing tannic acid, and I can see little difference whether the loss be occasioned by injury or by heat. The two chief methods of preparing the area for grafting are :—

(i) The complete immersion of the patient or limb in a saline bath for long periods each day. The intervening dressings consist of saline packs applied either direct to the wound or over a layer of *tulle gras*. In either instance frequent changing is necessary, to avoid drying and sticking. Occasionally, on account either of the position of the burn, or the condition of the patient, saline pads are sufficient without bathing. If the bath can be used it is desirable, in that it is possible thereby to maintain joint function throughout the whole period prior to the application of a graft. In addition, alteration of the strength of the saline may prevent transudation of tissue fluid and perhaps even result in some fluid absorption through the destroyed skin. The loss of serum proteins can be made good by intravenous infusion, and the chloride loss by mouth.

(ii) The use of sulphonamide powdered on to the wound at least once a day. This in turn is covered by the dressings described above and seems to be adequate in keeping infection under control.

Here we have a method which (*a*) does not inflict further trauma ; (*b*) does control infection ; and (*c*) does encourage tissue regeneration. The method is at once simple and difficult to apply. It means much nursing work and has many loopholes for the ingress of infection. At the same time it is resulting in the early application of that best of all dressings—new skin.

The second main category of burns, namely, destruction of the full thickness of the skin, require early skin replacement. The usual method is to continue the treatment outlined under that category until the granulating area is clean and pink, and free from gross infection. By this time the general condition will have so far improved as to allow the patient to be subjected to a general anæsthetic. My personal preference is for the application of split skin to these areas to cover them in their entirety, and I prefer to remove the granulations with a blunt instrument before this application is made. Other workers favour the use of multiple pinch grafts applied over the granulations. In either instance pressure is obtained by the use of wool wrung out in paraffin-flavine emulsion, and bandaged firmly to the limb. This pressure is retained for at least one week, and at the end of this time any residual raw areas are treated expectantly until epithelialization is complete. Injuries in special situations, say, round the eyes, call for modification of this technique in the way of fixation. Injuries exposing joints or tendons may require the use of full thickness flaps instead of skin grafts, but, whatever the method of repair, it is becoming abundantly clear that the earlier it can be carried out the more satisfactory will be the results.

Hands.—It should be realized that the immediate sequel to any burn is local œdema. In most areas this has little serious significance. In the hands it is of the utmost importance, for upon its occurrence depends the decision as to the form of treatment. Tannic acid applied early, even with all the full panoply of its adherents, will form an inelastic glove over the whole hand. It will prevent transudation from occurring. It will splint the fingers. The story will always be the same ; the patient will be comfortable for twelve to eighteen hours ; for the next three or four days he will suffer intense pain, controlled only by morphia. At the end of this time the pain ceases and so does the vain attempt of the circulation to defeat the ever-increasing tension against which it is working. On the eighth or tenth day a little pus begins to seep out of the various cracks in the armour, and finally the coagulum separates off, piece by piece, to expose a hand partly covered by thin scar, without a great deal of the subcutaneous tissue of the fingers, probably without one or more terminal phalanges, and with every joint and all the extensor tendons embedded in a mass of fibrous tissue, which is caused partly by organization of the original œdema, and partly by infection.

It is true that burns of less extent, not involving the whole circumference of the hand, do not behave thus, but so serious is the result of tannic acid in extensive burns that I would not hesitate to ban its use on any burned hand.

Face.—This area, too, is subject to the ban, chiefly because the multiplicity of orifices makes the avoidance of secondary infection almost impossible, and there is also the point that the texture of the scar occurring beneath the tan is not the best which can be obtained.

Section of Otology

President—LIONEL COLLEDGE, F.R.C.S.

[*December* 6, 1940]

DISCUSSION ON CAUSES OF FAILURE IN THE TREATMENT OF ACUTE OTITIS MEDIA

Mr. T. B. Layton: If an acute otitis media is allowed to become chronic, the patient may die from it; but he does so from an intracranial complication in forty years' time, when the doctor who treated him is sleeping under the turf of a churchyard, and any failure to cure the condition cannot be brought home. Deafness may result, and when the child goes to school he cannot get that advantage from his education that otherwise he would have. This deafness remains and lowers the wage-earning capacity still more. For these three reasons it behoves every doctor to get well every case of acute otitis media that comes under his care; and by *well* I mean a dry ear and a normal hearing.

Inflammation of the middle-ear cleft is primarily a bacteriological problem. At first there is an infection from a nasopharyngeal organism. Then there is a secondary infection from the skin of the meatus. The condition is then "chronic". Secondary infection is not likely to have occurred before the end of the sixth week after rupture of the drum-head. It may have occurred at the end of the eighth week. It is likely to have occurred by the end of the tenth week. Our crucial period, therefore, in curing this condition is from the seventh to the ninth week.

I know no better example in the whole of surgery than that of the pathology of mastoiditis of the scientific principle of Huxley that an hypothesis may over a long period do good work and yet finally prove to be wrong. Twenty years ago the hypothesis upon which everybody was working was that which may be described as the *hypothesis of successive jumps*. The inflammation went up the Eustachian tube and stayed there; sometimes it went into the middle ear; sometimes it went into the mastoid and the mere presence of pus in this warranted operation. There is no doubt that our seniors were working on that hypothesis, though it was enunciated most dogmatically by the late Mr. Charles Heath, with his description of the Eustachian, the attic, and the mastoid dams. We now know by radiography that an inflammation spreads through the whole of the middle-ear cleft into the mastoid region from the very first invasion of that cleft, and there is no absolute pathological dividing line between mastoiditis and acute otitis media. We may define acute otitis media as an inflammation of the middle-ear cleft which, in the acute invasive stage, shows no signs of endangering life nor signs of so much damage to the tissues that operative surgery will be necessary. Acute otitis media may be divided into two stages—the acute invasive stage and the period of reaction and repair. It is wrong to call the latter a "subacute" otitis media. A subacute otitis media is one which goes through the same phases, but in the acute invasive stage is clinically not strongly marked.

The vast majority of cases of otitis media get well by themselves. It remains for us to cure the small number that remain. Chronic otitis media is only common in communities where nutrition is deficient both from the caloric and from the vitamin point of view. No medical man need be proud of curing an otitis media in a well-nourished child brought up under good hygienic conditions. Our problem is to get well the remaining cases that do not cure themselves in patients who do not have these advantages in life. Primarily a bacteriological problem, inflammation of the middle-ear cleft is therefore secondarily a nutritional one, but there is much that we can do locally to help.

The first cause of failure is the way in which paracentesis is still repeatedly done in the early stage of otitis media. This is pathologically wrong, and clinically has been proved to be so. The experience gained in the Metropolitan Asylums Board service over ten years proved this. Except in the case of the child who keeps the family awake for the second or third night in succession, paracentesis, in my opinion, should not be performed in the acute invasive stage.

The next thing is the use of wet preparations. It is a dermatological principle that the skin organisms need moisture in which to grow. No antiseptic that is put into the external auditory meatus will kill an organism unless at the same time it destroys the superficial epithelium. It is not that the antiseptics do particular harm, it is that they are dissolved in water, and the water keeps the external auditory meatus moist, thus favouring the development of organisms which pass into the middle-ear cleft.

Then sufficient attention is not paid to external dirt. It is only during the last few years that I have realized the vast importance of controlling the hair. The perforation in the drum-head is a very short distance away from the pinna. Sometimes a wisp of hair will pick up the discharge and produce a festoon of small cutaneous lesions. That is not a very serious matter, but it is a serious matter if the other end of that festoon is the conjunctival sac with a conjunctivitis. I have once known that go on to a corneal ulcer, which, fortunately, did not perforate. The only way to prevent this is to control every strand of hair from the first moment. It is surprising how many cases will suddenly clear up after having resisted treatment over a long period if the hair is put under control.

The next matter is attention to the nasopharynx. The final recovery of cases of otitis media depends upon Eustachian drainage ; but the prevention of recurring infection from the nasopharynx is an important factor. I do not believe that sinusitis is the common thing in children that it is believed to be by some people, but if it is I believe it can be cured by the same treatment as that for a rhino-pharyngitis. I am a great advocate of nose-blowing. Whether all mucus or muco-pus has been expelled from the nose can be told with the same certainty as the condition of the lungs can be told by means of the stethoscope. By spatial auscultation the coarse râle of the mucus-laden nasal fossa can be heard to give way to the high-pitched " bronchial " breathing of the clear nose.

After this the siphon douche is most useful. There is no danger in this if it is not used in the acute invasive stage and if the container is not held further above the patient's head than he can hold it himself.

After attention to the nasopharynx, or, rather, as a part of it, I lay the very greatest stress upon posture as a therapeutic measure. There is no better way of preventing, or of curing, otitis media than by causing the person to take up the erect position. If children with an acute infection of the upper respiratory tract are treated in the erect position—or the semi-erect, that is, 45 degrees—there will be far fewer cases of otitis media. In the case of a child who cannot be got into the erect position one should make it lie prone and nurse it in that way. There was a block in the Southern Fever Hospital full of cases of whooping-cough from Christmas until Easter, but there was never a single case of otitis media. I asked the sister how she managed it, and her reply was, " I sit them up in the erect position and "—this is what I learned from her—" I do not mop unless there is really something to mop ". I am an enthusiast for mopping the ear in order to remove the discharge that is in the meatus, to stop that discharge making the skin wet, and so enabling the organisms to grow, but I know that my enthusiasm has at times led me too far, and I believe that with a super-enthusiasm an infection may be driven through instead of being removed.

I pass on to other measures of ensuring Eustachian drainage. These methods depend upon the movement of the palate, and that infers activity and happiness. The operation for adenoids at this stage is surgically wrong, therapeutically a failure, and entirely unnecessary. It is surgically wrong because a wound is being made on a recently inflamed mucous membrane on which are living hæmolytic streptococci or other nasopharyngeal organisms. It is therapeutically ineffective because the portion of lymphoid tissue which is causing the obstruction, namely, the small mass of lymphoid tissue in the submucous layer of the cartilaginous Eustachian tube is inaccessible to the curette. Even if the other lymphoid tissue which is temporarily enlarged is curetted away one has still to wait for the swelling in the Eustachian tube to go down before Eustachian drainage is effected. But it is not merely the lymphoid tissue which is involved, it is a general swelling of the whole of the mucous membrane of the nasopharynx and its submucous tissue. It takes

time to cause that swelling to go down, and one cannot hurry Dame Nature by performing an operation that is nothing more than the wet-cupping of the old-fashioned therapeutists.

In order to ensure Eustachian drainage the child must be happy. A child with a stolid face cannot be got well of otitis media. That is why the unmitigated scoundrel and the born flirt do not get otitis media, or if they do they get well by the processes of Nature. With every single movement of the face, with the exception of the movements in crying, the soft palate goes up and comes down again and for a short period exerts a negative pressure upon the nasopharynx. That was pointed out to me by the late Mr. Wilfred Trotter when he was explaining the rationale of his treatment of epistaxis. At some stage in the phases of the movement of the soft palate there is a suction on the Eustachian tube. The pull of some of these numerous muscles causes it to open and encourages the necessary drainage. The other movement of the pharynx which gives rise to Eustachian drainage is the movement of chewing.

In addition to all this there is needed the increased circulation through the inflamed area that can only be obtained by activity. The patient should be running about and undertaking physical exercises which, however, must not be too vigorous. You cannot get a discharging ear well while the patient stays in bed. During the winter months, when exercise may have to be carried out in a confined space, the finest form is skipping. The best form is a "varied eight" and the sister of the ward and all her nurses should be capable of doing it. It consists of two skips with both feet, two with the right foot, two with the left and two with both feet again. I started with sixteen, but I found it was too much for my breath, and if it is too much for me it is probably too much for a patient recovering from an acute streptococcal disease.

One or two other methods of treatment are of occasional value. If there is a perforation with an exuding bead of mucus, and at one sitting it is sucked out with the Siegel speculum until no more appears, one will occasionally obtain a brilliant result, and the ear which has been discharging for many months will clear up. Another is secondary paracentesis. Occasionally there will be seen on the drum-head a reddish pyramid with a white head. This is a bead, not of mucus, but of pus. If paracentesis be done, once again the discharge of many weeks may cease and the ear get well.

An important point is the condition to which Mr. Tumarkin has drawn attention. The discharge at the bottom of the external auditory meatus causes the epithelium to become white and to peel, and underneath this there is a small superficial ulcer. This piece of epithelium should be removed and a mild ointment applied to the ulcer. When this is done the ear which has been discharging for weeks may at once get well. Mr. Tumarkin says that ether is the best thing to use. I have never dared to try it for fear of pain. I use a stick dipped in glycerine passed down the canal. On removing the mop it will be found tinged with rose pink and one may think that the child has been hurt unnecessarily. Actually that is not so. The tinge comes from a little blood on the ulcer underlying the epithelium, and this has to be got away, though there may be a little pain in the process. Then vaseline or some mild ointment can be applied and the part left for forty-eight hours. If at the end of that time the discharge is no longer obvious one can be confident that the ear is well. Alternatively peroxide is of value, but peroxide is made up with water and there is also sulphurous acid in it, which is a skin irritant. It needs care in its application, and afterwards the whole of it must be removed by mopping. Then vaseline or other ointment may be used to cover the whole of the meatal wall. The question of moisture in the ear was very fully considered at our discussion on war injuries a month ago, but its importance needs emphasizing.

Finally, there is the question of the "clearing up" mastoid operation. If at the end of six weeks the ear is not well the advisability of opening the mastoid has to be considered. There is a condition in which there is disease in the mastoid region without its having given rise to enough symptoms to call it a subacute mastoiditis. It has been called a silent mastoiditis. If a patient, sent up as a case of mastoiditis but thought only to be suffering from an acute otitis media, does not get well at the end of a month, it is probable that the original observer was correct in suggesting mastoiditis, and that there is disease there which will not get well without operation. When that is the indication I do not advise waiting for as long as six weeks.

There are two other symptoms on which we may lay great stress. One is deafness, the other is the persistent pulsation inferred from the movement of a point of light thrown back from the depths of the meatus. It is not the degree of the accompanying deafness

or the presence of the pulsation that is important, but the persistence of either or both up to the fifth or sixth week which gives one an indication that a "clearing-up" mastoid operation should be done, other things being equal, without further delay. It is at this stage that radiography may be of value, not so much in enabling one to make up one's mind, as in giving confidence by means of confirmatory evidence, and anticipating the cautious sceptic who wonders whether the operation is really needed.

It was the late Dan Mackenzie who first urged the opening of the mastoid in these cases as a means of post-aural drainage. I am convinced that Dan Mackenzie's hypothesis of post-aural drainage is wrong, because in those cases in which I have found little or no disease I have had failures. The true explanation of it is the principle referred to by Lister in his original paper, that "an inflammation tends to get well by itself when the cause of the irritation is removed". It is the products of inflammation in the mastoid region, which cause the irritation in the middle ear, and according to Listerian principles it is the removal of the cause of irritation which results in the ear getting well. I lay very great stress upon the clearing up of the mastoid, but the more attention and the greater care that are given to these other points, particularly Eustachian drainage, the less do I find the clearing up of the mastoid to be necessary.

Mr. E. Musgrave Woodman: The middle ear is a plain cavity lined with mucous membrane containing ossicles which are strictly speaking outside the cavity. The danger arises from the open communication with the mastoid and the nasopharynx.

Apart from complication, it would seem difficult to understand how failure in the treatment of acute otitis media could occur. However inadequate the opening in the drum for drainage may be, or however badly the drum puncture has been carried out, it would seem impossible not to secure adequate drainage in view of the fact that the patient is recumbent for twelve hours out of the twenty-four, and would presumably lie on the affected ear for part of this time.

I suggest, therefore, that failure in treatment is due solely to the presence of complications, whether suspected or not.

The first and most obvious cause of failure is a persistent suppuration in the Eustachian tube, which probably has its origin in an active or latent sinusitis. This suppuration of the tube is often inadequately dealt with, and I would call attention to the use of a Eustachian bougie, so often advocated by our senior colleague Sir James Dundas-Grant. This bougie can be medicated and when dipped in silver nitrate has proved a very valuable asset in my hands.

The second cause of failure is an unsuspected mastoid involvement. A little while ago I had a case of subacute otitis media when the middle ear was full of brownish fluid, and the patient made the spontaneous observation that when he lay down he could hear perfectly well, but on standing up again he immediately became deaf. This patient's drum was punctured five times under cocaine anæsthesia before the fluid finally settled down, and it is clear that the whole mastoid cleft was involved in the inflammatory trouble although there were none of the signs which we know so well of mastoid disease.

A less common cause of persistent trouble is invasion of the ossicles, which is a complication.

It is a curious feature that it is possible to have an inflammation of the middle ear which settles down in the very restricted area around the head of the malleus and the body of the incus, i.e. the attic region. Why it should remain localized and almost encysted in this position, I have never seen satisfactorily explained. But many of these cases have a quite patent Eustachian tube and air can be blown into the middle ear. The mastoid is quite clear to X-rays and to transillumination, and yet there is a definite area of persistent infection in the attic region. This may settle down with fibrosis of the ossicles, leading to an intractable deafness, or perforate through Shrapnell's membrane leading to persistent suppuration. The only adequate treatment in my experience is by drainage through the mastoid antrum.

The last and most interesting complication and cause of failure is the presence of the tubercle bacillus. I believe this condition to be more common in this country than is generally recognized. Our colleagues in Copenhagen and Stockholm appear to have considerably more cases of this type.

In a case of persistent low-grade infection the presence of tubercle should be always under suspicion. In a case I had last year the patient developed a large painless hernial protrusion in the upper and posterior half of the drum, causing complete deafness in

this ear. The diagnosis was not in doubt as she was known to be tuberculous. At the end of nine months when the condition appeared to be on the point of bursting I advised a cortical mastoid operation. This was carried out, the wound sterilized with Bisform and completely sutured without drainage and the result was satisfactory.

I submit that this is the correct treatment for tuberculous disease in the middle ear if perforation has not taken place. It can be followed with advantage by X-ray treatment. If perforation of the drum has taken place and sepsis added to the already present tuberculous infection, the condition is a serious one, and I am inclined to think that the right treatment is to lay the whole part open by a radical mastoid operation, and to give X-rays or Finsen light.

To sum up—the treatment of an uncomplicated otitis media should not fail, therefore an unresolved otitis media is due to complications, which should be carefully searched for and eliminated.

Mr. J. Douglas McLaggan said that, like most acute infective conditions, acute otitis media usually had a limited course and was brought to a standstill largely by the natural defences of the body. There was, of course, another side to this picture, as was shown by the large number of cases of chronic suppurative otitis media which came to the out-patient clinic, also by the frequent discussion of this subject in medical societies, and the numerous operations which had been devised to deal with the infected labyrinth.

Within the last few years an extremely powerful weapon of defence had appeared in the drugs of the sulphonamide group. These agents lessened the amount of acute mastoiditis and gave fresh hope to the attack upon the most severe complications of that disease. It would be somewhat churlish to ascribe the triumph not to the potency of the drug but to a drop in the virulence of the streptococci, but the day had not yet come when any "super-prontosil" could be guaranteed to arrest the organism before irreparable damage had been done, and until then they had to make the most of their existing defences.

He desired to say a few words about one such weapon of defence. Anyone who had experienced the dramatic relief of pain and stress which paracentesis could give did not require to have the benefits of that operation impressed upon him further. But there was not the same unanimity about the indications for its performance. One author had put it very briefly, that in severe cases of inflammation where it was believed that perforation was certain to occur paracentesis should be performed. That seemed plain enough to him when he read it, but the same author spoiled it by advocating paracentesis for a much milder form of inflammation, namely, those cases of persistent catarrhal exudate in the middle ear where there was no sign whatever of any impending perforation.

The clinical diagnosis was very often easy. There was the reddened bulging tympanic membrane and the point of impending necrosis on the surface. These, with the severe pain, the temperature and so on, made up altogether a convincing picture. But there were cases in which the diagnosis of pus in the middle ear was much less easy, and there were no absolutely pathognomonic signs. In those difficult cases in which there was real doubt, with a sick patient it was probably better to perform a paracentesis early than to delay it for too long. Early paracentesis had been advocated almost as soon as the ear began to ache and the membrane began to be injected, and one of the grounds given for its performance was that it could not do any harm. There should be a sincere attempt at diagnosis before paracentesis was done for relief of pus, and if there was no pus present the operation was wrongly done. There was no unnecessary operation which might not do harm. Even the mere administration of an unnecessary anæsthetic to a sick child might do harm. The middle ear, which had been traumatized unnecessarily, might be most susceptible to any subsequent infection. There seemed to be an optimum time for the operation of paracentesis, and this time must be sought for and awaited, although its determination in middle-ear infections might not always be easy. A too early paracentesis might lead to a rapid spread of infection. He had mentioned in passing the danger of paracentesis for catarrhal exudate in the middle ear. He believed a secondary infection was very prone to occur, especially with patients where frequent dressings with strict asepsis were a difficult matter to arrange.

He did not wish to exaggerate the difficulties of paracentesis as an operation, but possibly they contributed to their failures by taking it too light-heartedly. Too often it was left to the house surgeon who had had no training in aural surgery apart from his work as a student, and operation was attempted with a meatus packed at its deeper half with debris. The difficulties were added to by the fact that the patient was often a child with a

relatively small meatus. The operator should be taught to clean out the meatus thoroughly, and when performing a paracentesis he should use the head lamp, for it was impossible to handle three instruments with two hands. It was usually laid down that the site of the incision should be through the most bulging part of the membrane, but in all English textbooks this site was invariably illustrated as being in the posterior segments. In view of this it was curious that the site of spontaneous perforation was so often in the anterior portion in the tympanic type of infection.

Paracentesis carried out through an apparently bulging membrane might fail to find pus immediately, and relief of symptoms was delayed for a varying length of time. This would seem to be due to the tympanic cavity being mostly obliterated by œdematous mucous membrane. This offered an explanation why a secondary paracentesis, carried out either after spontaneous perforation had occurred or to supplement what had been judged to be an inadequate incision, failed to bring about the expected relief. Attempts to establish better drainage by repeated paracentesis were doomed to failure, and by causing an excessive trauma to the membrane might produce adhesions and endanger hearing. It was very rare for the symptoms to be relieved by a secondary paracentesis.

He added a few words about post-operative care following paracentesis. Here there was greater risk of too much local treatment than of too little. The main object of post-operative treatment should be to keep the meatus free of pus and debris. He preferred mopping out the meatus with a simple solution of alcohol and peroxide. Peroxide was anathema to many otologists, but he had not been able to convince himself that it had done any great harm, and in individual cases it had been of great help in getting rid of blood-clot. The repeated insertion of gauze wicks might cause trauma and set up a secondary infection of the meatus. He had not found any advantage in the use of various dye antiseptics, and he disliked them because they obscured the picture. A paracentesis opening had a natural tendency to remain patent for as long as there was pus to be drained out of the middle-ear cleft, and very little good and considerable discomfort was caused by the use of suction to promote drainage. Œdematous mucosa might protrude through the opening. He thought that this should be left severely alone. It would subside along with the acute inflammation.

Mr. F. C. Ormerod said that he wished to draw attention to the question of paracentesis. In previous discussions on this subject some speakers had stated that they were opposed to the performance of this operation and left Nature to effect a perforation.

Mr. Musgrave Woodman had mentioned four causes of failure in the treatment of acute otitis media, and to these he would add one other, namely, mismanagement. He felt that to allow an abscess to remain unopened in the middle ear was mismanagement, especially when causing great pain. In no other part of the body was a collection of purulent fluid allowed to remain. The Eustachian tube was the ideal portal of departure of this fluid, but it was already inflamed, and along with this acute inflammation in the middle-ear cleft, the damming up of blood and possibly other fluids in the submucous tissue of the Eustachian tube would increase the congestion. The best way of opening the Eustachian tube was by relieving the pressure from the middle ear, and that was one of the reasons why he did a paracentesis at an early stage. Mr. McLaggan said that a paracentesis could be done too early and with this he agreed. If there was only a slight degree of swelling in the posterior segment and a rosy red appearance barely reaching the handle of the malleus, one could afford to wait, but when the colour had changed to a blue-grey and the bulging spread over the handle of the malleus the time had come to intervene.

He believed that Mr. Layton had based many of his conclusions upon the acute otitis media that occurred in infectious diseases, and this might be the reason why Mr. Layton's experience seemed to be at variance with that of the speaker and of other otologists. It was pointed out to him there by the medical officers of a fever hospital, who had been trained by Mr. Layton, that in such cases, particularly in scarlet fever, there was a continuous infection from the nasopharynx which went on much longer than in the case of colds and other like affections. The treatment therefore needed to be different because even if the mastoid were opened, one still had the infection remaining in the nasopharynx and reinfecting the tissues on which operation had taken place.

Mr. W. I. Daggett said that there appeared to be a great deal of uncertainty as to when paracentesis should be done. Mr. Mollison had previously laid stress on profound

deafness as an indication for opening up the mastoid. He himself felt that hearing was a good guide as to when paracentesis should be carried out.

Mr. C. Hamblen-Thomas said that if there was pain immediate relief ensued on doing paracentesis, and if there was a high temperature, this immediately fell. If the inflammation or abscess in the middle ear were allowed to persist, pathological changes would continue and fibrous tissue replacement with permanent damage to the contents of the middle ear would take place.

Mr. Terence Cawthorne said that most of the discussion so far seemed to have centred round the indications for paracentesis. From what he had heard of the discussion he was uncertain when the treatment of acute otitis media was considered to be a failure. He thought it could be said that it was a failure when it did not heal without operation—he did not mean paracentesis but a mastoid operation. He thought the causes of failure could be grouped under two headings, firstly, neglect in the early stages to apply the general principles guiding the treatment of inflammation, and, secondly, the infection being greater than the resistance of the patient. Mr. Layton had stressed the importance of the latter factor in the under-nutrition seen in the poorer class of patient.

As regards general principles of treatment, namely, warmth, rest, drainage, and removal of cause, local heat by means of some form of fomentations or hot electric pad with a bandage and rest in bed in the early stages were important. The question of drainage was straightforward. The mere presence of fluid was sufficient to warrant advising paracentesis. It was very important not to impede the drainage in any way, and here he wished to agree with one thing that two previous speakers had mentioned, namely, the use of peroxide. Peroxide undoubtedly caused irritation in the inflamed ear and that would produce swelling. The question whether one should mop or syringe was a matter of individual taste. He could not see any harm in syringing provided the meatus was dried afterwards.

As to removal of the cause, everybody had spoken so far about the nasopharynx. He thought that the nose was a more frequent source of trouble. Certainly this was so in adults and he would have said that at least 75% of cases of acute hæmorrhagic otitis had an infected antrum, and that required treatment simultaneously with the ear. He did not agree with the use of the nasal douche in acute infections of the nose. He thought it favoured the spread of infection from the nasal cavity to the sinuses and ears.

Mr. K. Eisinger said that he believed a great part of the treatment, determining its success or failure, depended upon the attention given to general conditions of the patient, but he attributed great influence to the anatomical and histological structure of the middle ear and mastoid process. Whether treatment was successful or not could only be revealed by statistical inquiry, and in order to be of scientific value such statistics must consider many points. Cases, to begin with, must be classified from the bacteriological and ætiological points of view. Ballenger found that mastoid operation was necessary in between 1 and 2% of cases following scarlet fever, whereas in the cases of *Streptococcus mucosus* (pneumococcus Type III) otitis the operation was necessary in 11%. The statistics should also have relation to the pneumatization of the mastoid, the age of the patient, and the season of the disease. If all these points were to be considered a single group was too small to permit of conclusive figures. Many years ago he had occasion to assist at Neumann's Clinic in compiling statistics relating to 13,000 cases of otitis media following the common cold, and it was found that operation had to be done in 1,300 or 10%. In the majority of cases the operation was for mastoiditis ; in other cases the operation was carried out in order to shorten existing complications or to prevent them from becoming chronic. Paracentesis was performed in most of the cases at the beginning of the otitis for relief of pain. From another source in Central Europe particulars had been obtained of 6,000 cases of acute otitis following the common cold. Here, a paracentesis was practically never carried out and in order to avoid unnecessary mastoid operations, it was customary to wait about six weeks before performing them, but again operation took place in about 10% of the cases. Altogether it appeared that, save in tropical climates, where still more favourable conditions prevailed, from 90 to 94 out of every 100 patients with acute otitis had a fairly good chance of spontaneous recovery following the usual methods of treatment. The remainder were the so-called failures which were : early complication in the first days or the first week, mastoiditis, post-operative complications or chronic otitis. Whether paracentesis was able to diminish the number of the early complications had not yet been proved. All that could be done was to discover the cases

as early as possible by exact clinical and neurological observation and sometimes by lumbar puncture. How the coming of the chronic state could be avoided other speakers had already explained convincingly. A treatment which would avoid mastoiditis in all cases had not yet been discovered. Certainly paracentesis could not prevent the development of mastoiditis in every case. Experiments were made with X-rays, short-waves and diathermy, but the results were not convincing, and the same applied to all kinds of injections and vaccines, and to artificial fever therapy which had been tried. One thing which was needed was a definition—he used the word definition deliberately, not standardization—of the indications for opening the mastoid. Some of the cases which were now acknowledged failures, had they come into the hands of another operator who had dared to wait longer before operating, might have proved a success. But on the other hand it must be considered that mastoiditis was the link between acute otitis and endocranial complication, and therefore as a prophylactic the operation must not be performed too late. To avoid the post-operative complications it was necessary to standardize the operation in the form of the so-called " mastoidectomy ".

Summing up, his opinion was that though the fate of a patient with acute otitis depended a great deal upon the anatomical and histological structures of the middle ear and mastoid process an improvement of therapeutic methods could diminish the number of failures.

Mr. T. B. Layton (in reply) maintained that the diminution in virulence of the hæmolytic streptococcus came before the advent of chemotherapy, and that it was likely to become virulent again. These transient diminutions in virulence of the hæmolytic streptococci had occurred previously. The best example was afforded by scarlet fever which Sydenham described as scarcely worth being called an illness. But in the middle of the last century scarlet fever was extremely virulent. In the year 1921 the Metropolitan Asylums Board had the largest number of cases of scarlet fever in the whole history of the Board, and with these enormous numbers, the virulence diminished. During the thirties also there had been a diminution in the virulence of the hæmolytic streptococcus before chemotherapy came in, and he maintained that one had to be most careful not to assume that the diminution in the hæmolytic streptococcus was due to the sulphonamides.

With regard to paracentesis the general approach to it was now very different from what it was at the end of the last war and the differences of opinion as to where it should be performed and how it should be performed, might be due to the fact that they were calling different diseases with different pathology and different methods of spread by the same name. Many years ago when he started work at the Metropolitan Asylums Board he accepted the teaching of his seniors, particularly Sir William Milligan and Mr. Herbert Tilley, that paracentesis should be done at the earliest possible moment in every single case of otitis media. It was still largely done by people who received their education twenty years ago. But this was the only part of the body where it was considered a right surgical procedure to incise an acutely inflamed area that had not yet localized.

He thought the question of when to do a paracentesis in the acute condition turned upon the definition of the word " pain ". If a child woke up at night and brought about a restless night for the whole family and if at about six o'clock the next evening it seemed likely to be going to have another night of the same kind, one should perform a paracentesis to relieve the pain and secure rest. But if the child was merely whimpering, and when put down in its cot and after a few pats tumbled asleep, it could be taken that it was not suffering enough pain to make it necessary to do a paracentesis. He also wished to commend Mr. McLaggan's point that if one was to do any good in otology at all one must be able to use the frontal mirror and to clean the ear, and he criticized those teachers in the schools who were teaching students to use an electrical apparatus or a " diagnostic set " as distinct from the frontal mirror.

On the question of clearing up an acute otitis media which did not perforate, he had not had very much experience, and he did not know whether certain of the cases of permanent deafness in adult life were due to the adhesive processes occurring in a middle ear which had been inflamed but had not perforated.

Section of the History of Medicine

President—Sir Walter Langdon-Brown, M.D.

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David Hartley: Physician and Philosopher (1705—1757)

By Sir Walter Langdon-Brown, M.D.

My interest in David Hartley was first aroused by the fact that Coleridge named his eldest son after him, trusting "that his head would be convinced of, and his heart saturated with the truths so ably supported by that great Master of Christian Philosophy". But like so many of Coleridge's schemes, this went agley, for the son lost his Fellowship at Oriel for drunkenness and the father was to spend many hours of his later life in trying to refute Hartley's teaching. It was yet another of those paradoxes which characterized Coleridge's career, that the son, named after the philosopher he came to reject, survived his father, while the one he named after Bishop Berkeley, to whose philosophy he clung, died in infancy. The second thing to interest me in David Hartley was that he was a physician, and that he attempted to develop his philosophy from a physiological basis. But it was not until I read Mr. Basil Willey's admirable *Background of the 18th Century* that I realized that in point of view as in point of time Hartley stood midway between Newton and Wordsworth, a bridge between Cambridge physics and Lakeland pantheism.

The publication of Newton's *Principia* in 1687 not only initiated a new era in physics, but, like the work of Copernicus, Darwin and Freud, its influence extended over many other fields of thought, and dominated eighteenth century ideas, particularly in theology. Alexander Pope voiced the common feeling when he wrote :—

> "Nature and Nature's laws lay hid in night:
> God said, 'Let Newton be!' and all was light."

The main feeling seems to have been one of relief from the strain of living in a mysterious universe; supernatural and occult explanations ceased to satisfy and the universe came to be regarded as a great machine—it certainly seemed to work as perfectly as if no fall of man had ever taken place. There was a steady decline in the tragic sense of life, and poetry sang flat. Yet, as we are learning to-day, the deification of the machine has produced a new juggernaut which has renewed the sense of tragedy.

David Hartley was born at Armley in Yorkshire in 1705, the son of a country clergyman. After being educated privately, he entered Jesus College, Cambridge, at the age of 15, of which college he subsequently became a Fellow. When Coleridge entered the same college seventy years later, it was becoming a centre of intellectual ferment, but in Hartley's time it was one of the sleepiest colleges at a somnolent stage in the history of the university. However, he who seeks for intellectual stimulus will generally find it and although Newton had by then left Cambridge to become Master of the Mint, Hartley was his enthusiastic admirer and disciple and studied mathematics under Sanderson, his successor. He was also on friendly terms with Robert Smith, Professor of Astronomy and afterwards Master of Trinity, now chiefly remembered as the founder of Smith's Prizes, still a great distinction in mathematics. He also became very friendly with Stephen Hales, Fellow of Corpus, of blood-pressure fame. The story of Hales' opportunity to embark on experimental science is rather amusing. The Mastership of Trinity, unlike that of other colleges, is in the gift of the Crown, and in 1700 Richard

Bentley, a Johnian, was appointed. As at that time the traditional rivalry between Trinity and St. John's was at its height, the Fellows of Trinity fiercely resented this, and barred the great gate against his admission. To this day a formal barring of the gate is still carried out against a new Master until he produces his letters patent. Bentley, once installed, converted the building now known as the Old Bursary into a laboratory, quite as much to annoy the classical dons as from any great affection for science. However, this gave Stephen Hales his chance to carry on investigations on animal and plant physiology, in which he made use of his mathematical and physical training at the hands of Newton. He retained his association with David Hartley long after their Cambridge days, as we shall see. Hartley was originally intended for the Church, like his father before him, but found the 39 Articles more than he could conscientiously subscribe to, and so although he remained a loyal member of the Church he decided on a medical career, since, as he said, "the great differences of opinion and contentions which happen on religious matters are plainly owing to the violence of man's passions more than to any other cause". He therefore felt he could serve his day and generation better by the practice of medicine, which he carried out with success at Newark, Bury St. Edmunds, London and Bath. His son gives a very pleasant impression of his personality and appearance. Of medium height, and fair complexion, his features are said to have been regular and handsome. He was particularly neat in his person and attire. He was very sympathetic with suffering, placid in temperament and eminently sociable. Music, poetry and history were his favourite recreations. His whole character is summed up as marked by sincerity of heart and simplicity of manners. We may conclude that the man was in harmony with his philosophy to an eminent degree. It is not surprising, therefore, that he numbered among his friends many distinguished men of the time; in addition to those already mentioned there were Bishop Butler, of the famous Analogy, Bishop Warburton and Bishop Hoadley, of Bangorian controversy fame, Dr. Young of the *Night Thoughts* and, rather unexpectedly, Alexander Pope.

It was presumably his keen sense of justice which led him into the only controversy in which we know him to have been engaged, when, in the latter part of the 1730's, there was a considerable stir occasioned by the claim of a certain Mrs. Joanna Stephens to have a sovereign remedy for the stone. This distressing condition was, as we know, very prevalent, and Professor J. C. Drummond has recently called attention to an interesting reason for a change in incidence. Until towards the end of the seventeenth century it afflicted the well-to-do more than the poor, because Galen's belief that fruit and vegetables tended to excite fever still held the field, so they were looked upon as poor men's food and were left to them. When this belief was abandoned the richer classes secured most of the supply of such foods and the poor went without. Recent research has shown that the most important single factor in the causation of renal calculus is diet, particularly shortage of vitamin A. Even in the middle of the eighteenth century the problem was a topical one, and in 1739 David Hartley addressed a book to the President and Fellows of the Royal College of Physicians, in which he collected the evidence for and against Mrs. Stephens's remedy, and reported some experiments of his own. He said that he hoped when Mrs. Stephens published her whole method and medicines that they would then be tried out both in private practice and in hospitals. He was persuaded that when this was done she would appear in a different light from common pretenders. He gave notes of 155 cases and came to the following conclusions:—

(1) The treatment is in general innocent and safe. Very few seem to have received any injury from it, which is as much as can be said of any efficacious medicine.

(2) These medicines have done great service in the stone and gravel. He thought that they would do more good if given under the direction of physicians if they would take it up.

(3) These medicines do not make the flakes and fragments which appear as has been alleged. They contain alkaline salts and are diuretic; they cannot be stone generators. Soap, which seems to be the other part of the medicine, is given by the best physicians for gravel. The flakes and fragments which are passed show that they must have been separated from the surface of a stone.

(4) The cases cannot be accounted for by accident.

(5) The urine of those that take these medicines has a stone-dissolving power.

He went on to propose that a sum of £5,000 be raised by contribution and that trustees should be appointed (which included various distinguished people, such as the Archbishop

of Canterbury and the Lord Privy Seal) and that as soon as this money was raised, Mrs. Stephens should reveal the composition of her medicines, which should be made public, and that Mrs. Stephens should receive the interest of this sum until such time as sufficient trials had been made of the medicines and that she should receive the principal if it appeared to the Trustees or to a majority of them that the medicines were able to dissolve stones. But if this did not appear the principal should be returned to the contributors. He published a first list of contributors, amounting to £1,387. Whether the total sum was subscribed I know not, but Parliament evidently took some steps and the formula was published. The subject aroused sufficient interest for Dr. John Rutty to present a communication to the Royal Society in January 1741 in which he stated, "The Medicine, as communicated to the Publick, is a Composition operose and troublesome, several Parts of it being of little or no Use, and others plainly calculated to disguise the rest. The Ingredients of which it consists have lately been examined by the ingenious Dr. Hales and Dr. Hartley, who have with much Judgment rejected the superfluous Parts, and reduced this pompous Medicine to a slacken'd Powder of calcin'd Egg-shells, and a Solution of Soap. . . ." The "ingenious Dr. Hales" was, of course, the Stephen Hales already referred to. Rutty made further experiments on the comparative efficacy of dulcified spirit of nitre, spirit of salt and decoctions of onions, leeks and celery, to which was subjoined an account of the effects of soap-lees taken internally in the case of James Jurin, M.D. All these observers relied a good deal on the solvent effects of their solutions *in vitro*, though Dr. Rutty admitted that, reasoning from the effects of medicines on stones out of the body to their effects on the same stones in the body, where those medicines may undergo great alterations, is not always conclusive. He claims, however, that these experimental observations and the clinical results corresponded well enough to provide "a reciprocal illustration and confirmation of each other". Here surely is an instance of the great difficulty of arriving at the truth in therapeutics, for we find a number of sincere researchers, at least one of them a distinguished scientist, reaching the conclusion that there is evidence in favour of treating renal calculi by the administration of calcined egg-shells and soap-lees. Perhaps some person may care to repeat their observations! I came across a curious sidelight on these experiments in the diary kept from 1647-1672 by the Rev. John Ward, who afterwards became Rector of Stratford-on-Avon. Ward was sorely tried to decide between the Church and physic for a profession, for there was a great scientific revival while he was at Oxford, as evidenced by Bathurst (with whom Harvey studied embryology), Thomas Willis, Richard Lower, Christopher Wren, and Wallis, who was Glisson's first pupil. Sir D'Arcy Power, who transcribed these diaries, quotes this injunction, which Ward urged on himself, "Remember in all my dissections to aim at the discovery of a passage between the stomach and bladder". If it was still believed in Hartley's day that such a communication might exist, it would explain the tendency to argue from experiments *in vitro* to therapeutic effects *in vivo*.

The important and interesting thing about David Hartley to us to-day is, however, his *magnum opus, Observations on Man*, first published in 1749; important because it considerably influenced later eighteenth century thought; interesting particularly to medical men as an attempt to build up a system of philosophy and theology in stages from physical, physiological and psychological considerations. Academic philosophers have not infrequently complained of our contemptuous indifference towards their subject. I should not so describe it myself, but it must be admitted that our objective method of training does make for imperfect sympathy between us and them. Hartley's philosophy, based as it is on natural science, is more comprehensible to us, even if we cannot accompany him on his higher flights into theology. Instinctively his inductive method makes an appeal, because it involves the conception of continuity. And, although this may be thought to be special pleading, I feel that a biological training, such as medicine necessitates, is less likely to leave the mind divided into watertight compartments than is a purely mathematical and physical one. How otherwise can we account for such a genius as Isaac Newton producing both the *Principia* (which, incidentally, he seems to have regarded as a parergon) and the commentary on the *Book of Daniel*, of which he was inordinately proud, although it reads to-day like apocalyptic nonsense. And quite recently we have seen the distinguished inventor of the thermionic valve denying *in toto* the process of evolution, principally on Biblical grounds.

Although Hartley was 43 when he published his work, he tells us that he began it when he was about 25, and that the idea was germinating for some years even before that

early age from hearing that Gay had asserted the possibility of deducing all our intellectual pleasures and pains from association (of ideas). He completed it two or three years before he published it, in case modifications might occur to him or be suggested by others, but even up to his death nine years later he left his original version quite unaltered, saying that now his mind was left in perfect repose. He did not expect that it would meet with any general or immediate reception or even that it would be much read or understood; neither did it happen otherwise than as he had expected. But at the same time he did entertain an expectation that later on it would become more generally accepted; this also happened.

He started from two postulates, on the physical side Newton's theory of vibrations, on the mental, Locke's theory of the association of ideas as laid down in his essay on the Human Understanding. It is only natural that this famous work by one physician-philosopher should appeal to another of similar training and outlook. Thomas Hobbes had earlier adumbrated the idea of what we should now call conditioned reflexes. The special merit of Hartley seems to me that he invoked the theory of vibrations to explain conditioned reflexes, and conditioned reflexes to explain in turn the association of ideas. He accepted Newton's conception of an all-pervading ether through which vibrations of varying wave-length were transmitted, and agreed with him that the nerves are solid cylinders, and not hollow tubules as Boerhaave maintained. They were, he imagined, of just such a density of composition as to have a selective capacity to transmit the waves from the sense-organs to the brain, and stated that such "vibrations must be regarded as exceedingly short and small so as not to have the least efficacy to disturb the whole bodies of the nerves or brain". It is true that modern physiologists, in the words of Best and Taylor, regard the nervous impulse as resembling "a spark travelling actively along a train of gunpowder rather than a wave transmitted passively through air or water", but that our sensations are initiated by vibrations of different wave-length impinging on sense-organs still holds the field. Indeed, Hartley was himself critical of his own theory concerning the method of transmission of nervous impulses and admitted that his doctrine of vibrations might be fictitious, but thought it might be a useful working hypothesis providing a scientific method of approach to psychology. He considered that the doctrine of association would hold whatever became of the hypothesis of nerve vibrations. He called attention to Newton's observations on the persistence of visual impressions on the sensorium and suggested that "sensations by being often repeated leave certain vestiges, types, or images of themselves which may be called simple ideas of sensation". Further, that "any sensations A, B. C, &c., by being associated with one another a sufficient number of times get such a power over the corresponding ideas, a, b, c, &c., that any one of the sensations A, when impressed alone, shall be able to excite in the mind b, c, &c., the ideas of the rest". Then "simple ideas will run into complex ones by means of association", and "It is reasonable to think that some of the complex vibrations attending upon complex ideas may be as vivid as any of the sensory vibrations excited by the direct action of objects". It appeared to him that all the most complex ideas arise from sensation and that introspective reflection is not a distinct source of ideas, as Locke had maintained. He confessed that his whole conception is "necessitarian" or, as we should express it to-day, "determinist", but that he did not realize this until several years after he had begun his inquiries. This placed him on the horns of a dilemma between a materialistic determinism and the free-will demanded by the orthodox theologian. And Hartley remained to an astonishing degree theologically orthodox. He devotes a concluding chapter of 12 pages in his first volume to an attempt to resolve this dilemma, which doubtless was more satisfactory to him than to the modern reader. However, in great detail he elaborates his conception of vibrations affecting the brain substance, inducing conditioned reflexes (as we should say) and leaving memory traces which are the foundation first of simple and then of increasingly complex ideas. He concluded that: "All the sciences, knowledge of all kinds, may be reduced to the 7 general heads. . . . First, Philology, or the knowledge of words and their significations. Secondly, Mathematics, or the doctrine of quantity. Thirdly, Logic, or the art of using words considered as symbols for making discoveries in all the branches of knowledge. Fourthly, Natural history. Fifthly, Civil history, i.e. transactions of the world politic. Sixthly, Natural philosophy. Seventhly, Religion, which might also be called divine philosophy." It is not so easy for us to trace the logical development of his theology from his psychology as it is to see the connexion between his physiology and

his psychology, for even though, as is inevitable, much of his physiology is out of date in points of detail, the groundwork remains fairly sound. It is of more interest to us to observe the extraordinary modernity of some of his incidental ideas. Thus, he really grasped the significance of referred pain, and almost in the same words as Sir Henry Head used about one hundred and fifty years later pointed out that internal pains will send up impulses to the same region of the spinal cord as those coming from the surface of the body, so that "the physician may from his knowledge of the situation of the internal parts in respect of the external, guess pretty nearly what internal part is affected". He pointed out the reason why the distribution of the nerves to internal parts "will give rise to many deceptions . . . and in certain cases make the pain to be felt, i.e. appear to be, in parts a considerable distance from the seat of the disorder". He also attributed, as Sir Arthur Hurst does, the sensation of hunger to contraction of the stomach muscles, and ascribed the analysis of sounds by the ear to vibrations of particular fibres of the lamina spiralis of the cochlea. He called attention to the large olfactory lobes in lower animals compared with man and drew the appropriate deductions, saying, "it seems to me a very striking coincidence that mankind should at the same time exceed the brute creations in the variety of their ideas and in the proportional largeness of that part of the body which is the peculiar seat of these". [This resembles Sir Chas. Sherrington's remarks in his recent Gifford Lectures.] He put forward a pleasure-pain principle not unlike that of Freud, and utilized it as part of his system of ethics. He realized that "we do not take notice of or are offended by the inconsistencies [of dreams] . . . for the associations which should lead us thus to take notice are as it were asleep". I was particularly entertained by his comparison between our dreams and the pronouncements of the prophets. "As the prophecies were, many of them, communicated in the way of divine visions, trances or dreams, so they bear many of the foregoing marks of dreams. Thus, they deal chiefly in visible imagery; they abound with apparent impossibilities, and deviations from common life, of which yet the prophets take not the least notice: they speak of new things as of familiar ones; they are carried in the spirit from place to place; things requiring a long series of time in real life are transacted in the prophetical visions, as soon as seen; they ascribe to themselves and others new names, offices, &c., everything has a real existence conferred upon it; there are singular combinations of fragments of visible appearances; and God Himself is represented in a visible shape, which of all other things must be most offensive to a pious Jew." This seems to me striking, but I was not so impressed by his deduction therefrom that it proved their divine authenticity.

I come now to certain comments and criticisms on his work. The famous chemist, Dr. Joseph Priestley, who was a Nonconformist divine as well, was much interested in David Hartley's views and corresponded with him concerning them. In 1775 he published a volume entitled *Hartley's Theory of the Human Mind on the Principle of the Association of Ideas, with Essays on the Subject of it*, and it may well be that this contributed to the increased attention those views received towards the end of the century, partly by denuding them of the more mechanical parts of his vibration theory. In 1772 Herman Pistorius produced a German translation printed at Rostock and at Leipsig to which he added an extensive commentary. This was translated and published as a third volume to the 1791 editions of Hartley's work, together with a short biography by David Hartley, junior. At the turn of the century Sir James Mackintosh, in his lectures at Lincoln's Inn, said that Hartley stood in the same relationship to Hobbes as Newton did to Kepler, the law of association being that to the mind which gravitation is to matter.

In 1817 Coleridge published quite an extensive criticism of Hartley in his *Biographia Literaria*. Having read it, I came to the conclusion either that Coleridge did not understand Hartley, or that I did not understand Coleridge. Perhaps both; and certainly I should not be the first to fail to understand Coleridge. He was, no doubt, correct in tracing the doctrine of association back to Aristotle, whose position on the subject was, he claimed, "unmixed with fiction". He was quite contemptuous of the approach to the subject by physiologists, whom he dismisses as "dreamers" (of dreamers Coleridge might fairly claim to be a good judge) and states that where Hartley differs from Aristotle he differed only to err. He does not seem to appreciate that Aristotle gave a description without attempting an explanation, and his comprehension of Hartley's theory is sufficiently illustrated by his assumption that it involves every idea having a nerve of its own. No doubt it was more difficult to appreciate Hartley's views when the arrangement of

neurons, and the existence of myriads of association cells were unknown; it is all the more to the credit of Hartley's philosophic insight that, in effect, he forecast their discovery, but that he should have been thought to have enunciated a slogan of "one idea, one nerve" illustrates the disadvantage of an absence of scientific training, even for a philosopher. The force of one of Coleridge's criticisms must, however, be admitted, and it stares every reader in the face; Hartley's second volume on theology really makes no reference to the principles or results of the first. For myself, I felt very strongly that, whereas he developed his physiology from physics, his psychology from his physiology and his ethics from his psychology, he starts his theology from strictly orthodox conceptions without any induction from his previous conclusions. Had he really been able to have evolved his second volume from his first he would have achieved a masterpiece.

It is clear that by 1817 Coleridge had departed far from the views he held in 1796. What is more strange is that if, as he tells us, he was an enthusiastic admirer of Plotinus when he was only 15, he should have had any sympathy for Hartley's views when he was 24.

Leslie Stephen proved himself a much more perceptive critic. The copy of Hartley that I read formerly belonged to him and is enriched by his notes, unfortunately often unintelligible because he sometimes used a private system of shorthand. But his *English Thought in the Eighteenth Century*, published in 1876, contains his considered judgment. He maintained that "Hartley had the merit of really improving our conceptions of the mode in which moral sentiments are generated in the individual. So few men have really added to our limited stock of moral theories that the merit must be regarded as a very high one. On the other hand, the value of Hartley's speculation is confined to this branch of ethical speculation". And again, "Hartley was philosophically a materialist. . . . Yet turn over a few pages and [he] appears in the character of a Christian advocate, refuting the infidel by the same arguments, though not with the same brutality as his friend, Warburton. Go a little further and it might appear that Hartley is a disciple of Spinoza, to whom the highest good is self-annihilation and absorption in the Deity. Certainly a strange combination; and yet it must be added that Hartley is a consecutive reasoner whose theory sins rather by excessive simplicity than by undue complication". . . . "The final value of Hartley's system was the impulse given to the attempt to resolve complex into simple intellectual operations by the help of the law of association. . . . The theology is an addition to the creed and not a natural development. . . . The old ideas were simply retained in their old shape, and retained at the price of an unnatural alliance."

Hartley's latest commentator is Mr. Basil Willey, in the book to which I have already referred. He says, "his significant contribution is his joining up a materialistic psychology, not with a Hobbist pessimism, but with the optimistic theism of his century to yield a confident faith in the necessity of progress towards perfection. He thus contributed to the stream of tendency which flowed into the nineteenth century as philosophic radicalism, and also as Wordsworthian naturalism". I must not diverge from my main topic by tracing Mr. Willey's fascinating analysis of Wordsworth, in whom he discovers primitive animism refined into pantheism, through the influence of Hartley's philosophy via Coleridge, but I cannot refrain from quoting his final judgment, "For many an escaped Puritan or overwrought intellectual in the nineteenth century and for many a sufferer from the disease of modern life, looking up from among the dark Satanic mills of the industrial age, the authority of the Wordsworthian Nature religion has seemed absolute. Nevertheless, it was probably only relative to a certain passing phase of civilization: for an age and not for all time". Perhaps one might describe Sir William Hale-White's father, who wrote under the name of Mark Rutherford, as its last exponent.

At first sight it seems a far cry from the *Principia* to the *Prelude*, yet one can see how the study of natural law led to the development of natural theology, which under emotional tension could become a pantheistic worship of Nature. Yet one must admit the force of Aldous Huxley's remark that Wordsworth's Nature religion was the product of "the cosy sublimities of Westmorland", while "Nature in the tropics is apt to produce worship of the devil rather than of God".

John Buchan, too, contrasted the Nature benign of Wordsworth with the Nature malign of the tropics, and finding South Africa unlike either, said, "It was a refreshment to be in a world so superbly impersonal, so divinely inhuman, and I found Wordsworth

irrelevant". Anyone who has been on the high veldt will appreciate that remark. Its sublimities are certainly not "cosy".

Here I must leave our physician-philosopher, in the hope that I have been able to convey something of what I believe to have been his influence on the transition of thought between the seventeenth and nineteenth centuries. He has left a gracious impression on my mind, at any rate. All the aspects of life which interested him he attempted to integrate into his own philosophy, and so he became a whole man. No one need wish for a happier epitaph.

Life and Times of Jean Nicolas Corvisart (1755—1821)

By J. F. Halls Dally, M.D.

The stirring events of the beginning of the nineteenth century cannot have failed powerfully to impress the mind of Corvisart, who for many years was in close contact with the Emperor Napoleon. They are also of interest to us, forming as they do a striking parallel with our own times.

Historical Comparison

In order to give Napoleon time to reopen the struggle with England, the Peace of Amiens (1802) was made at his request, only to be repudiated by him a year later. He was determined to become master of the Western world, and no ideas of popular freedom or sense of national right interfered with his resolve. In the autumn of 1805, after intensive preparation, the invasion of England was planned on a gigantic scale; a camp of a hundred thousand men was formed at Boulogne, and a host of flat-bottomed boats assembled for their conveyance. Unable to secure the three days' calm requisite for such purpose of conquest, suddenly with terrific energy he left the English Channel and swept eastwards to further victories. But already he had met his real defeat. Napoleon had lost his chance of world domination, not in Moscow, not in Spain, not at Leipzig, nor even at Waterloo. He lost it on that day when he was compelled to leave his camp at Boulogne, forfeiting to Britain the opportunity further to strengthen her might, to gather her allies, and finally to deal the decisive stroke of retribution.

Jean Nicolas Corvisart

From this vivid comparison with the present war we turn to the subject of this study. Jean Nicolas Corvisart des Marets was born on February 15, 1755, in the hamlet of Dricourt, near Vouziers, then a part of Champagne but now included in the Department of the Ardennes. The family can be traced back to A.D. 870, and was ennobled in 1669 in the person of Henri de Corvisart, Lord of Fleury.

Childhood.—Pierre Corvisart, the father of Jean, was an advocate and attorney to the Parliament of Paris. When the Parliament was exiled, Corvisart the elder left with his associates and settled temporarily in Dricourt, returning to Paris soon after the birth of his son, whom he destined for the Bar. The father had previously possessed considerable means, most of which had been wasted on inferior paintings. For reasons of economy, Corvisart the younger was sent for part of his childhood to live with an old uncle, the parish priest of Vimille, a village some few miles from Boulogne. At the age of 12 he entered the celebrated college of Sainte-Barbe, where he proved a pupil mediocre in attainment, devoting himself mainly to outdoor sports. He is said to have left the college almost as ignorant as when he went in, with no reputation but that of an incorrigible idler. Thus the childhood of Corvisart gave no promise of his brilliant future.

Youth.—While still a law-student, playing truant whenever he could, he visited the medical clinics of Paris and was so fascinated by what he saw that he determined to study medicine. Having neither pecuniary means nor influence he obtained a position as a male nurse at the Hôtel-Dieu, the oldest hospital in Paris, for which he received board and lodging with opportunities of studying medicine. Here he came under the influence of the eloquent Professor Desault. Thus he forsook the Codes of Justinian for the Staff of Æsculapius, and escaped from the paternal ægis, which so angered his father that he kicked him out of the paternal home.

Having thus lighted on a congenial occupation, Corvisart while still young achieved distinction and became liked by physicians and patients. When the time came to choose

between medicine and surgery, he preferred medicine, to which he was more attracted. He followed assiduously the teachings of the founders of clinical study in France, namely, Desbois de Rochfort, Busquet, Hallé, Pelletan, Roger, Vicq d'Azyr and Portalo and was a favourite pupil of Antoine Petit, Louis and Desault, later becoming their friend. Corvisart often prepared material for their demonstrations, on one occasion endangering his life through a septic scratch-wound, from the results of which he was saved by the science and devotion of Desault.

Qualification.—Youngest in his class, Corvisart soon stood at its head. On September 2, 1782, he presented his inaugural thesis. Three years later, in 1785, the degree of Doctor-regent was conferred on him by the Faculty of Medicine of Paris. According to custom he gave an address dealing with the joys of medical study and the disappointments of practice. This was followed by a banquet to his teachers and fellow-students. When the festivities were at their height, Corvisart became unable to discourse except in Latin, and astounded the professors, who were dining in a separate room, by bursting in upon them with ejaculations from Latin authors, which brought the banquet to an abrupt termination.

The degree of Doctor-regent was not easy to obtain, involving as it did no less than six years of applied study insufficient to cover the groundwork of the examination, so that much self-education became necessary. By this time the young man is seen to have put off the mantle of sluggishness and to have assumed that of painstaking endeavour.

Appointments.—Corvisart later became demonstrator of anatomy and opened private courses in anatomy, physiology, obstetrics and operative surgery. He was appointed physician to the parish of Saint Sulpice, but often was obliged to borrow money in order to perfect himself for a career. He much desired a hospital post, and was regarded as a suitable candidate to be recommended for the post of physician to the hospital that Necker had then recently founded, but on Madame Necker insisting that he should wear a powdered wig, the current fashion for physicians of that time, he forthwith declined the honour!

Meantime he had become the close friend of Desbois de Rochfort and Desault, as well as of Father Potentian, Superior of the Charité Hospital. On the death of Desbois in 1788, Corvisart was elected his successor as physician to that hospital. Desbois de Rochfort may be regarded as the real creator of clinical medicine in France. The pupil thus succeeded the master, and the glory of the master gained added lustre. Corvisart took over the clinical teaching and from that moment his reputation, already established among his colleagues and students, began to spread outside the confines of the hospital. While his predecessor restricted himself to simple and familiar talks with chosen pupils, Corvisart, marching in the wake of Stoll, imitated the stately clinics of Vienna, and marshalled hospital, students and patients like an army. He gave an impetus to pathological anatomy by demonstrating that the chief aim of medicine should be not to elicit by sterile curiosity what post-mortem peculiarities might be found, but to strive to recognize the presence of particular diseases by their appropriate signs and symptoms. Reveillé-Parise, then a medical student, has told how Corvisart, perceiving him one day at the Charité, abruptly asked what he had come for. "To study", replied the young man, a little upset by this brusque reception. "To study", exclaimed Corvisart, smiling, "that is good, my friend; here"—pointing to the patients—"are the books you need, but they are not as easy to read as are printed books."

Then in 1793 the Reign of Terror began. The medical schools were shut, anyone could call himself a doctor and treat the sick. Medical education was three centuries behind the times. But out of the Revolution grew modern medical education. In the new schools of Paris laboratories were instituted for scientific study; students were taught at the bedside in hospital after the manner of Sydenham. And it was Corvisart—formerly rejected because he wore no wig—who taught, for he had now become the leading professor in France. He acquired the natural history of disease by collecting observations, and when possible, following the example of Morgagni, he noted from dissection and from autopsy the changes in the body that caused symptoms of disease. His chief lectures were given at the Necker Hospital, and subsequently over a term of fifteen years at the Cochin Hospital.

Corvisart, whose reputation increased daily, lived in close contact with the most illustrious men of the time. In 1795, on the creation of the first school of medicine in

Paris, he was unanimously elected to fill the Chair of Clinical Medicine, for the first time included as a part of public education in France. Two years later, in 1797, he was made Professor of Medicine at the Collège de France.

Corvisart's first meeting with Bonaparte.—We come now to the Directory, the supreme executive Council from 1795 to 1799. At a brilliant soirée given by Barras, with whom Corvisart had become acquainted through Lecoultelx de Cauteleu, one of his first patients, Corvisart was presented to General Bonaparte, when the delightful Josephine, who had implicit faith in the knowledge of the great physician to the Charité, asked him point-blank, "To what disease do you think the General is most likely to be exposed?" "To disease of the heart", imperturbably replied the oracle. "Have you written a book on that?" asked Bonaparte. "No, but I think of publishing one soon." "Then lose no time, we will speak of this later." It is possible that suggestion from this august source led to the appearance a few years later of Corvisart's important book on the circulation.

By the time that these two men first met, Corvisart had already become one of the cleverest practitioners of his day, and was at the head of one of the greatest hospitals in Paris, the Charité. During his ten years there those who went round the wards with him in the forenoon could go later to the Collège de France and hear the same cases discussed from the theoretical standpoint.

Corvisart's method of investigation.—His first procedure was to observe the patient as a whole, paying particular attention to physiognomy and tongue, next to the characters of the pulse, afterwards to examine the chest by palpation and by percussion with the finger-tips. Endowed by Nature with remarkable acuity of touch and hearing, he became so expert that the admiration of his students was evoked by the dexterity with which he practised percussion after the manner of Auenbrugger, as well as by the accuracy of his prognosis.

At times one is astonished that Corvisart came across more heart disease and aneurysms than did any of his predecessors or contemporaries. However, the renown of Corvisart, together with his success in treatment, attracted to him more than to any other physician a special following who thronged his consulting room and hospital.

Honours.—In 1799 Barthez and Corvisart were jointly made physicians to the Government; on the death of Barthez, Corvisart became by decree personal physician to Bonaparte as First Consul. With the advent of the First Empire, Corvisart attained the distinction of becoming chief Physician to the Emperor, Empress and Court.

Napoleon valued his frank and disinterested outlook, characterizing him as "a clever and honest man, but a little brusque". His honesty of character was never more in evidence than when he refused an official post for his brother, saying that it demanded an aptitude that his brother did not possess. The three men whom Napoleon respected most for their frankness and honesty were Corvisart, Larrey and Percy, all medical men. On December 12, 1808, the Emperor rewarded Corvisart's services by creating him Baron of the Empire, Officer of the Legion of Honour, and Commander of the Order of the Réunion. In 1811 he was admitted a Member of the Academy of Sciences, and of the Academy of Medicine in 1820.

At this time the medical staff of the Emperor consisted of Hallé, as physician-in-ordinary, Boyer as chief surgeon, and Yvan as surgeon-in-ordinary. When invited by Napoleon to select a surgeon-in-chief, in preference to Dubois, Corvisart chose Boyer, believing that because of his humble origin and noble character he would never exhibit to the Emperor a dominating spirit, but from natural modesty would be content to efface himself. Nevertheless, Napoleon had the most profound esteem for his first surgeon, who is best remembered for his work on *Maladies chirurgicales.*

As physician to Napoleon I.—For long Napoleon was reluctant to call in Corvisart, and it was only on the instance of his secretary, Bourienne, that he finally decided to do so. Six months elapsed before Napoleon asked his secretary for the name of his doctor, and on being told that it was Corvisart who had cured his brother, even then the First Consul did not hasten to avail himself of the services of this able practitioner. The real reason was that Napoleon wished to put medical science to the test, being always sceptical with regard to medicine, and had thus successively consulted Professors Sue, Pinel and Portal before he called in Corvisart. None impressed him so much as did the latter by his penetration, promptness and precision, as well as by his frankness and the finesse of his repartees. "Never was a man less pliable, less prepared for the post of

courtier: he formed part of the Imperial Court, but not of the domestic life of the palace. In his distinguished post he comported himself with all the dignity of character that belongs to a physician. Further, Corvisart did not abuse his credit, but, on the contrary, exercised it with much discretion."

Being taken suddenly with cough, pain in the chest and stained expectoration whilst in Brussels, Napoleon had Corvisart summoned on August 16, 1803. Corvisart at once diagnosed pulmonary congestion, but was too wise to alarm the patient by telling him so. A vesicant relieved the malady. Much later Napoleon remarked in reference to this incident: "I saw that Corvisart understood my system, and that he was the doctor who suited me, so I attached him to myself."

On Wednesdays and Saturdays the First Physician attended when the Emperor rose and retired. Even though Napoleon was in his morning bath, Corvisart was at once admitted. If the august patient was in good humour he was wont to greet him thus: "Ah! there you are, great charlatan, how many patients are you going to kill to-day?" "Not many, Sire", was the usual reply. With Corvisart the Emperor omitted all formality, often pinching or rubbing his ears, a trick of his with those whom he liked. Napoleon was inclined to distrust medical art, claiming that it was too conjectural. By reason of his numerous ailments he was difficult to manage. He was always cold, and had a fire in his study even during the summer. He took a daily prolonged hot bath, followed at Corvisart's suggestion, by vigorous friction with Eau de Cologne. Napoleon was averse from drugs, believing that they should be reserved for exceptional cases, hence his treatment by Corvisart depended mainly on hygiene. Charlatans received scant mercy from Napoleon, but he had the highest opinion of Bichat, Larrey and Corvisart.

In May 1809 Napoleon, when at Schoenbrunn, consulted an Austrian doctor named Joseph Frank, who diagnosed a grave eruption on the back of the neck for which lengthy and severe measures were recommended. Napoleon became perturbed and sent for Corvisart who soon arrived and, after inspecting the rash, exclaimed, "Frank exaggerated, you are doing well. To make me travel so far to apply a blister, which the last doctor could have done just as well as myself!" The eruption speedily yielded to this treatment and did not recur.

The Empress Josephine had previously been treated by Corvisart for the sterility which led to her divorce. Within two months the Emperor had married an Austrian Archduchess, Marie Louise, who presented him with a son, afterwards King of Rome, the accoucheur being Dubois. Corvisart's frankness later led to estrangement from Napoleon, for he opposed the Emperor's marriage to Marie Louise and finally advised her not to follow Napoleon into exile at Elba.

Corvisart's publications.—Corvisart himself wrote comparatively little. The total list of his publications amounts to five, in octavo form. In 1789 he edited the *Materia Medica* of Desbois de Rochfort, as well as founding the *Journal of Medicine, Surgery and Pharmacy* which went through 40 volumes. In 1797 he showed his fondness for aphorisms by translating from Latin into French *Aphorisms on the Knowledge and Cure of the Fevers* by Maximilian Stoll, published in 1785. Stoll was his favourite author, and he took him as his model and followed in his footsteps. After translating these aphorisms of the Viennese professor, he frequently used to comment upon them in his discourses and to imitate them in his practice. In 1802 Corvisart translated the aphorisms of the renowned Boerhaave.

In the same year (1761) that marked the publication of Morgagni's two large folios on *Sites and Causes of Disease*, which gained for its author the title of Father of Pathology, a small pamphlet was issued by Joseph Leopold Auenbrugger, a simple-minded, kindly and unassuming junior physician at the Vienna Hospital. This pamphlet, called *A New Invention for discovering Thoracic Disease by Percussion of the Chest*, went through two editions and embodied the results of six years' experience. It gave a complete account of the sounds obtained on percussing the chest and of their value in diagnosis and prognosis. Clinical results were confirmed by post-mortem observations. Thus, Auenbrugger may justly be claimed as the originator of the method. This *Inventum Novum*, however, received but slight appreciation till Corvisart, the leader of medical thought in France, then the centre of scientific development, published in 1808 a French translation with commentary and preface which did equal honour to the author and himself. With a fine sense of integrity he wrote in the preface: "I could have raised myself to the rank of an author by remodelling the work of Auenbrugger and

publishing a work on percussion. But by that I would sacrifice the name of Auenbrugger to my own vanity ; that I do not wish to do : it belongs to him, it is his beautiful and rightful discovery which I wish to bring to life." Corvisart's translation, with observations of his own, formed a volume of 480 pages and appeared forty-seven years after Auenbrugger's unpretentious pamphlet of 95 pages. Auenbrugger lived just long enough to witness the beginning of a proper recognition of his discovery.

This discovery became greatly enhanced in value on publication of the treatise *On Mediate Auscultation* by Laennec in 1819, about four years after he had invented the stethoscope. Less striking, but no less beneficial in its results, was the work of Bichat, the shortest-lived but one of the greatest heroes of medicine. He founded the new science of histology, and died in his 31st year, July 22, 1802, from a malady acquired in the dissecting room. The next day Corvisart wrote to Napoleon : " Bichat has just fallen on a battlefield which numbers more than one victim. No one has done so much and so well in so short a time."

Corvisart's own aphorisms are exceptional in that they were not made public until more than a century after his death. His follower, F.-V. Mérat, chief of the Clinic of the Medical Faculty of Paris, on the title-page of the manuscript stated that this collection of aphorisms should have been published with the consent of Corvisart, but that his duties as chief physician to the Emperor Napoleon forced him to give up his courses of instruction, and the work was not published. In recent times the manuscript was discovered in the archives of the Academy of Medicine of Paris, edited by the librarian, the late Dr. Paul Busquet, and published in 1929. The volume has now been translated into English by A. L. Mc Donald, with an account of Corvisart. The aphorisms are full of interest especially by reason of the intuitive faculty they display.

Corvisart's *magnum opus* entitled *Essai sur les maladies du cœur et des gros vaisseaux* appeared in 1806, followed by a second edition five years later, the third and last edition being published in 1818. It constituted the most notable French treatise on cardiac disease after the more philosophical one of Senac. It may be said that cardiology as such did not exist prior to Corvisart's work. He really created cardiac symptomatology, and established the differential diagnosis between cardiac and pulmonary diseases, as well as between functional and organic heart disease.

Corvisart's chief contributions to cardiology were (*a*) the differentiation between cardiac hypertrophy and dilatation. Chronic hypertrophic myocarditis was named after him, " Corvisart's disease ", (*b*) division of clinical heart failure into three periods, (*c*) relation between cause and effect in valvular lesions and heart failure, (*d*) study of the cardiac musculature and mention of congenital *morbus caeruleus*. He was the first to explain the mechanical causes of heart failure, effort dyspnœa, and the thrill felt over the præcordium in mitral stenosis. The facies of cardiac insufficiency was named after him " Corvisart's facies ". In the third edition is found one of the earliest references to adherent pericardium in a description of three cases that died within twelve months from the onset with œdema and ascites.

The book was dedicated in most graceful terms to the Emperor Napoleon, its plan exhibiting a regular order which must have appealed to Napoleon in its military spirit. It begins by a fine chapter devoted to general considerations of cardiac pathology, while the main body of the demonstration follows. In the first section are all the affections of the pericardium ; in the second, diseases of the cardiac muscle, including the so-called " aneurysm of the heart ". The third section deals with thickening and calcareous deposits in the fibrous portions, especially in those that surround the auriculo-ventricular orifices. The last portion is concerned with carditis and aortic aneurysms.

Helme believes that the chief influence on Corvisart's practice and writings was exerted by Stoll ; Bichat taught him the importance of autopsies ; finally, in order of influence come Desbois and Desault, with Boerhaave least.

Corvisart as physician.—Lassus has emphasized Corvisart's critical sense, independence, powers of observation and scepticism. Desbois did much to make an observer of Corvisart, who combined criticism with common sense, hence his diagnosis at times seemed well-nigh incredible. Probably he initiated routine physical examination, thus anticipating what is now the custom. Observation was termed by him the main support of clinical medicine. On seeing a portrait Corvisart is said to have exclaimed, " If the painter were exact, the original died from heart disease ". And he was correct. Often he was able to recognize the disorder present from a distance.

Character.—Scrupulously honest, Corvisart never gossiped. Generous with the poor, he insisted on adequate fees from the well-to-do. In the presence of strangers he was grave and reserved. He was fond of dreaming and reflecting. Dupuytren believed that Corvisart was always moody. Even at the zenith of his success he was morose, gloomy, and preoccupied. He was a good companion when he roused himself, but marital difficulties and the death of an only son are said to have accounted for this gloomy attitude to life. He married Anne-Marie Louise Drouillard, from whom he was divorced comparatively early in life. He was courteous to colleagues and to other doctors, save to some of the older school, whom in his direct way he termed "Gothic and antiquated". Favourite lay authors were Molière and Voltaire, whose habit of thought coincided with his own.

As therapeutist.—Relying more on Nature's efforts than on the efficacy of drugs, Corvisart employed them only when he thought they were really indicated, and then with extreme reserve, thus maintaining an expectant outlook with the issue of good results. He has been criticized for his lack of faith in drugs. For the most part he relied on common-sense measures, but when powerful drugs became necessary he did not hesitate to use them, as when the Duchesse d'Abrantès was cured by him of a serious gastro-intestinal complaint by the employment of opium.

Social life.—In the company of friends Corvisart shook off his habitual reserve and melancholy disposition and proved an entertaining companion. He delighted to gather about him not only physicians but also writers and artists. Robert Surcouf, a famous French corsair (after whom in recent days a submarine has been named) was one of these intimates who later became a Baron of the Empire. All were appreciative of good food and wine, including Brillat-Savarin, who wrote on the physiology of taste, and "Jolly old Baron Alibert", as Oliver Wendell Holmes calls him, founder of the modern school of French dermatology, to whom was always entrusted the carving of fowl or game at their dinners.

On December 6, 1808, the day of St. Nicolas, the leading artists, actors and actresses gave a fête in Corvisart's honour. Isabey painted twelve tableaux representing episodes in Corvisart's life, one showing him at the age of 30 receiving the 12 sous a week allowed him by his father. Artists from the Opera sang topical verses composed by Picard. In spite of becoming Fortune's favourite Corvisart was, however, seized from time to time with sensations of incurable boredom.

As collector.—Like all true amateur collectors, Corvisart preferred rare or curious objects that he had picked up to gifts that had been offered to him. Thus he became the possessor of a stick, upon which Voltaire had leaned for long, furnished with a bird's head of gold. Some days afterwards Corvisart presented himself to the Emperor carrying this latest trophy. Then ensued the following dialogue: "Why the walking-stick, Corvisart, are you hurt?" "No, Sire, but I exercise my privilege; the first physicians of the Kings of France had the right thus to present themselves before him." "But it is not pleasing; how can a man like yourself carry such a miserable stick as that?" "Sire, this was a very costly article, and I bought it very reasonably." "How much then did it cost?" "1,500 francs, Sire, but it is the stick of a great writer." "Who was that?" "Voltaire." "I do not like that man", quickly replied Napoleon, "he has shaken authority by corrupting public morals."

Pupils.—Corvisart had a throng of distinguished pupils and successors. The most famous were Bichat (1771-1802) the founder of biology; Bretonneau (1771-1862), the brilliant discoverer of diphtheria in 1826; Bayle (1774-1816) noted for his work on Phthisis Pulmonalis, in which he stated that the tubercle is specific. This careful work paved the way for Laënnec, and subsequent authors. Bayle was an ardent student of pathological anatomy, which did not prevent him from becoming a great practitioner who could see at a glance, this rapidity of observation having been learned from his master, Corvisart. Bouillaud (1796-1881) is celebrated for the first description of the cardiac manifestations of rheumatic fever; Dupuytren (1778-1839), the most representative French clinician of the early nineteenth century, who created the school of clinical surgery; Laënnec (1771-1862) who originated modern medicine when, in 1815, he discovered almost by accident that the heart beat and lung sounds could be heard clearly through a cylinder of card or paper held to the ear, the other end being applied to the patient's chest. Laënnec later substituted a cylinder of wood, the precursor of the stethoscope in its modern form. His fame became universal, but his efforts cost him

his life, for he died of lung disease acquired in his hospital practice. Cruveilhier (1791-1874) became famous as a pathologist and anatomist. He was the first to describe the spinal form of progressive muscular atrophy (Cruveilhier's palsy) and ulcer of the stomach was called after him Cruveilhier's disease. Various anatomical structures were also named after him. Piorry (1794-1879) perfected the method of mediate percussion in 1828 ; Rayer (1793-1867), by his pathological classification of skin diseases, antedated Hebra. Rayer's monograph on glanders and farcy in man (1838) is classical, and xanthoma has been described as Rayer's disease. Chomel (1671-1740), who devoted himself to natural history, completes the list of Corvisart's most famous pupils.

Latter days.—Corvisart had the opinion that after 60 years of age a physician was of little use because he lacked audacity. He retired from practice at 60 years fearing apoplexy. After the news of the disasters of 1815 and collapse of the administration Corvisart was smitten with his first attack of apoplexy, which was partial, but left some paralysis. He survived this for six years during which he had repeated attacks, the last on Saturday, September 15, 1821, to which he succumbed three days later.

His bust.—At the foot of the grand staircase in the Hall of the Pas-Perdus at the Paris School of Medicine is a fine bust of Corvisart. The countenance is noble and powerful, the nose arched and imperious, the mouth small and pinched, illuminated with a haughty smile, the chin self-willed, the forehead generously free, framed by thick and wavy hair, and with short whiskers descending over massive cheeks.

Summary

In the twentieth century the genius of Laënnec has well-nigh eclipsed the glory of his teacher, Corvisart, who is viewed by several biographers simply as "First Physician to the Emperor Napoleon I". But Corvisart has greater claims to medical fame. He rescued from oblivion the art of percussion invented by Auenbrugger, perfected it and made it widely known. If Laënnec was especially patron of the tuberculous, Corvisart was the father of cardiology; in other words, Corvisart did for the heart what Laënnec had done for the lung. The publication of Corvisart's treatise marks the beginning of the clinical study of cardiology. Above all, Corvisart was a great clinician, creator of the study of symptomatology, and the leading physician of his time, possessing a scientific position based on the excellencies of his character as well as on his diagnostic abilities. His critical spirit was individual and not inherited, and he combined this with common sense. His independence of mind allowed him to put into practice his estimable qualities without concern as to doctrine, opinion, authority or tradition. His acute powers of observation made him the first to utilize his senses in the examination of the sick, at the time a novel method. Healthy scepticism was a part of his nature, manifested by repetition of a too-often neglected truth: "What we know is little in comparison with what remains for us to discover." For him, as for Napoleon, medical science was not one of precision but of prevision. Thus he was renowned for his diagnoses, often made rapidly, but founded on the total characteristics of the patient. Like Hippocrates and Sydenham, Corvisart used only his hands and his senses in the study of disease. The principles he enunciated were elaborated by his pupils after his death with beneficent results to humanity.

Thus we close a record of the most salient features in the character of a man who knew his own mind, thought for himself, and put his ideas into practical operation. It only remains to acknowledge the help I have obtained from contemporary and later authors.

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DISCUSSION ON ACTIVE IMMUNIZATION—SOME PRESENT-DAY PROBLEMS

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Abstract.—*Diphtheria.*—Immunization is safe and effective. Compulsory measures are indicated, especially for the younger age-groups. The Schick test may be reserved for selected groups and to control modified methods. Proper spacing of doses of prophylactics and periodic reinoculation will ensure a high level of immunity. It is important to beware of "one-shot" methods. Indiscriminate swabbing is to be discouraged; high carrier rates are an indication for widespread diphtheria prophylaxis.

Enteric fever.—Mass immunization is desirable in many areas, although there is no justification for compulsion except for people exposed to special risks. In deciding upon dosage of vaccine, more attention should be paid to physical state and body-weight. After the primary course, very small periodic doses (for example 0.1 c.c.) are worthy of trial. Vaccine can be given during an epidemic without increasing the chances of infection.

Tetanus.— Two doses of toxoid spaced by six weeks give useful immunity. Women give significantly higher titres than men. A third dose of 1·0 c.c. after a long interval —seven to nine months—often produces a dramatic rise in circulating antitoxin, and counteracts any tendency to waning immunity.

Smallpox.—As vaccination has not been made compulsory in this country, infection by virulent strains from the continent may tax the resources of the public health services.

Whooping-cough.—The large number of injections of vaccine usually recommended is a deterrent to mass immunization. Research into the possibility of fewer doses and wider spacing is indicated.

Other diseases are considered briefly.

Combined immunization.—It may be useful to combine diphtheria T.A.F. and tetanus toxoid, also tetanus toxoid and T.A.B. vaccine. T.A.F. plus T.A.B. is probably contra-indicated for adults on account of severe reactions. Diphtheria A.P.T. should not be mixed with tetanus toxoid as it may go into solution and become ineffective.

Sterilization of syringes and needles.—An intensive inoculation campaign is no excuse for slip-shod methods.

Résumé.—*Diphtérie.*—L'immunisation est effective et sans danger. L'immunisation obligatoire est à recommander, surtout pour les plus jeunes enfants. L'épreuve de Schick peut être réservée pour des groupes choisis et pour contrôler des modifications de technique. L'espacement correct des doses de substance prophylactique, et des réinoculations périodiques assureront un haut degré d'immunité. Il est important d'éviter les méthodes à une seule dose. Les prélèvements dans la gorge sans discernement sont à décourager. Les proportions élevées de porteurs de bacilles sont une indication pour la prophylaxie générale contre la diphtérie.

Fièvre typhoïde.—L'immunisation en masse est à recommander dans beaucoup de régions, quoique la contrainte ne soit justifiée que chez les individus exposés à un risque spécial. En fixant la dose il est nécessaire de prêter plus d'attention à l'état physique et au poids du corps. Après la première série d'injections, de très petites doses périodiques (par exemple 0,1 cm^3.) méritent d'être essayées. La vaccination peut se faire pendant une épidémie sans augmenter le risque d'infection.

Tétanos.—Deux doses de toxoïde à six semaines d'intervalle donnent une immunisation utile. Les femmes donnent des titres beaucoup plus hauts que les hommes. Une troisième injection de 1,0 cm^3. après un long intervalle—de sept à neuf mois—produit souvent une augmentation dramatique de l'antitoxine dans le sang, et neutralise toute tendance à une diminution de l'immunité.

Variole.—La vaccination n'étant pas obligatoire dans ce pays, il est possible qu'une infection par des souches virulentes provenant du Continent pourraient mettre à l'épreuve les ressources des services d'hygiène publique.

Coqueluche.—Le grand nombre d'injections généralement recommandé fait hésiter devant l'immunisation générale. Des recherches sur la possibilité de l'emploi de moins d'injections sont indiquées.

D'autres maladies sont considérées brièvement.

Immunisation combinée.—Il peut être utile de combiner les toxoïdes diphtérique TAF et tétanique, ainsi que la toxoïde tétanique et le TAB. La combinaison de la TAF avec le TAB est probablement contre-indiquée chez les adultes à cause des réactions violentes qu'elle produit. La toxoïde diphtérique APT ne doit pas être combinée avec la toxoïde tétanique, parce qu'elle peut entrer en solution et perdre son efficacité.

Stérilisation des seringues et des aiguilles.—Une campagne d'immunisation intensive ne doit pas servir d'excuse pour des méthodes mal soignées.

RESUMEN.—*Difteria.*—La inmunización es innocua y eficaz. Medidas obligatorias son indicados, especialmente para los grupos de edad tierna. La reacción Schick se reservará por grupos escogidos y para controlar métodos modificados. El espaciar correctamente las dosis de profilácticos y la reinoculatión periódica aseguran una inmunidad sólida. Importa guardarse de los métodos a dosis únicas. Se desaconseja la toma rutinaria de exudados; un gran número de portadores indica que habemos de efectuar una profilaxia extensa.

Fiebre entérica.—La inmunización de las grandes colectividades es de querer en muchas localidades, pero no se justifica la compulsión excepto para los individuos que se exponen a riesgos especiales. En decidiendo las dosis de vacuna hay que dar más atención a la condición física y al peso corpóreo. Merecen el ensayo tras la serie principal pequeñitas dosis periódicas (p.ej., 0,1 c.c.). Las vacunas pueden administrarse durante una epidemia sin aumentar el riesgo de infección.

Tétanos.—Dos inyecciones de toxoide con seis semanas de intervalo confieren una inmunidad útil. Las mujeres muestran títulos significativamente más altos que los de hombres. Una tercera dosis de 1,0 c.c. tras un largo intervalo—de siete a nueve meses—causa muchas veces una elevación dramática de la antitoxina en circulación, e impide las tendencias hacia una inmunidad disminuida.

Viruela.—No siendo obligatoria en este país la vacunación, la infección por cepas virulentas viendo del continente puede sobrecargar los medios de los servicios de sanidad pública.

Coqueluche.—El gran número de inyecciones que en general se recomienda es obstáculo a la inmunización colectiva. Hay menester de investigaciones sobre la posibilidad de menos dosis a intervalos mayores.

Otras enfermedades se consideran brevemente.

Inmunizacion asociada.—Pueden asociarse útilmente los flóculos de toxina-antitoxina y la anatoxina antitetánica, también la anatoxina antitetánica y la vacuna T.A.B. Se contraindican probablemente los flóculos de toxina-antitoxina con T.A.B. para los adultos a causa de reacciones severas. No mezclar el toxoide precipitado por alumbre con el toxoide antitetánico ya que puede derretirse y hacerse ineficaz.

Esterilización de jeringas y agujas.—Una campaña intensa en pro de la inoculación no excusa métodos negligentes.

RESUMO.—*Difteria.*—A Imunisação é segura e eficaz. As medidas obrigatorias estão indicadas principalmente para as tenras edades. O processo Schick pode ser reservado para grupos escolhidos e para controlar metodos modificados. Um alto grau de imunidade pode ser obtido pelo distancimento cauteloso das doses de profilaticos e pela reinoculação periodica. E preciso ter muita cautela com o metodo de " uma só aplicação." O uso, á tôa, de tampões deve ser abandonado; quando aparece maior numero de pessoas transmissoras da doença devem-se tomar largas medidas de profilaxia.

Febre enterica.—A imunisação em massa é aconselhada em muitas localidades, ainda que não haja justificação para ser obrigatoria, exceto para os que estão expostos a grandes pèrigos. Ao decidir-se a dose de vacina a aplicar, deve-se ter especial cuidado com o estado fisico e o pezo do individuo. Depois do procedimento elementar, podem-se aplicar doses periodicas muito pequenas (por exemplo 0,1 c.c.). Pode-se vacinar quando grassa epedemia, sem perigo de aumentar as probabilidades de infeção.

Tetano.—Duas doses de toxoide com o intervalo de seis semanas dão a necessaria imunidade. As mulheres manifestam reacões mais elevadas do que os homens. Uma terceira dose de 1,0 c.c. administrada depois de longo intervalo—de sete a nove meses—

poduz muitas veses um notavel aumento na antitoxina circulante e impede qualquer tendencia a diminuir a imunidade.

Variola.—Como a vacinação não é obrigatoria neste paiz, a infeção causado por individuos vindõs do continente pode sobrecarregar os serviços da saude publica.

Tosse convulsa.—O grande numero de injeções de vacina geralmente recomendada é um obstaculo à imunisação em massa. Por isso se deve estudar a possibilidade de menor numero de doses e aplicações mais espaçadas.

Outras doenças.—São mencionadas brevemente.

Imunisação combinada.—Pode ser util combinar os floculos da antitoxina do toxoide de difteria com o toxoide de tetano, assim como o toxoide de tetano com a vacina antitifoide paratifoide. A floculos da antitoxina do toxoide de difteria mais a vacina antitifoide paratifoide são provavelmente contra indicadas para adultos por causa das serias reações produzidas. Precipitado de Alumen de Toxoide de Difteria não deve ser misturada com o toxoide de tetano por poder entrar em solução e tornar-se inutil.

Esterelisação de seringas e agulhas.—Uma campanha intensa de inoculação não deve servir de pretexto para desmazelos.

It is unnecessary to stress the importance of the specific prophylaxis of infection at a time when the exigencies of a second winter of war have led to overcrowding and bad ventilation in so many of our homes and dormitories and have lowered our standard of living. We have to consider what diseases can be dealt with effectively by preventive inoculations, and also whether in the case of at least one disease, viz. diphtheria, some measure of compulsion might not be necessary and urgent. Now is the time to institute our plan of campaign without waiting for some major epidemic.

I shall give a brief account of recent work at Beckenham, and shall deal with general principles rather than with practical details of the newer measures of control. Many of these methods, including the injection of a combination of antigens, are comparatively untried in this country.

Diphtheria

Diphtheria should never have been a "shelter problem", for immunization is safe and effective when intelligently carried out; unfortunately the bulk of the child population of this country has not yet been reached. In 1939, Sir John Ledingham advocated compulsory measures, and the need is all the greater to-day, especially for the younger age-groups.

How can procedure be simplified to facilitate mass immunization? The Schick test need seldom be performed in the present emergency. Proper spacing of the doses of modern potent prophylactics, and periodic reinoculation will ensure and maintain a high level of immunity in nearly 100% of persons. The Schick test itself, although of great value, has the usual biological defect of individual variation; for this reason many clinicians consider it advisable to inject one dose of diphtheria prophylactic into all "natural" Schick-negative persons, at the time of the Schick reading. If, as is now advocated, Schick-negative as well as Schick-positive persons should receive some further stimulation of their antibody-producing mechanism, we can reserve the test for selected groups only or to control any drastic modification of our methods necessitated by the war. For example, it has always been our policy to advocate two doses of diphtheria prophylactic A.P.T. separated by one month for children, but recently I advised the medical officer of a large industrial concern with many young employees to use two widely spaced doses of T.A.F. (incidentally combined with tetanus toxoid), a milder and somewhat less potent antigen than A.P.T., and one which has hitherto been given in three doses separated by periods of a fortnight. The doctor was anxious to reduce the incidence of reactions as much as possible, and also the number of injections. Here is a situation in which representative groups might be Schick-tested after immunization to check the value of the modified use of T.A.F. Nevertheless, if this small amount of testing is impracticable, criticism of the modification may still be answered when we remember that the important consideration to-day is to give some protection to as many persons as possible.

In our desire to reduce the number of injections we should beware of so-called "one-shot" methods. For inducing a high titre of circulating antitoxin more than one stimulus is necessary, and the length of interval between injections is more important than the size of the doses. My colleague, Mr. A. T. Glenny, has shown that in guinea-pigs two injections of 0·1 c.c. of A.P.T. at an interval of four weeks produce much higher antitoxic values than a single injection of 1·0 c.c. Single dose methods

are, of course, justified for a periodic re-stimulation to obtain a more durable immunity. Thus, in some hospitals, nurses are given 1·0 c.c. of T.A.F. every year, and practically never suffer from even mild diphtheria. Animal experiments show that the effect of very small single doses (e.g. 0·1 c.c. of T.A.F.) at long intervals is worthy of trial experimentally in man also, blood samples being taken to ascertain the antitoxic titres. If immunization is carried out during infancy a small periodic stimulus thereafter should do much to remove the bugbear of reactions.

Nasal immunization, which is a convenient though somewhat uncertain method of "boosting" a waning antitoxic titre, has made little headway in this country. Apparently some persons suffer inconvenience from reactions (as they would from reinoculation), but the method has definite possibilities and purified toxoids of high antigenic value might again be tried by the intranasal route.

Much has been said and written recently about the risk of high diphtheria carrier-rates in crowded rooms and shelters, and there is reason to believe that practitioners are wasting, and will continue to waste, the time and resources of bacteriologists by repeated and indiscriminate swabbing. Under war-time conditions there may be a shortage of guinea-pigs, and essential virulence tests may not be possible. Moreover, the number of diphtheria bacilli present in throat or nose is variable, so that swabs may be negative one week and positive the next. The type of culture medium employed in the laboratory also influences the result. Surely swabbing might now be discontinued except for persons with obvious abnormalities of the upper respiratory passages, and in special circumstances their immediate contacts. The possibility of high carrier-rates is an indication not for more swabbing but for more intensive and widespread diphtheria prophylaxis.

Enteric Fever

Vaccination against enteric fever should come next in order of importance. Damage to water mains and sewers, and improvised sanitary arrangements in different types of air-raid shelters make the risk of serious epidemics very real Mass immunization is now desirable in many areas, although so far there is no justification for compulsion except possibly for certain wholesale food operatives and persons exposed to special risks of infection. As is well known, the Army authorities give two doses of 0·5 c.c. and 1·0 c.c. of vaccine at an interval of seven to ten days. These doses were worked out in the first instance for young men in good physical condition, and more attention might usefully be paid to-day in civilian practice to the physical condition and body-weight of the persons to be inoculated. Many private practitioners now give three doses of 0·1 c.c., 0·5 c.c., and 0·75 c.c., or two doses of 0·25 c.c. and 0·5 c.c., especially to under-nourished men or to women, and have thus reduced the incidence of untoward reactions. With regard to children, body-weight is of less importance, and the younger age-group tolerate enteric vaccination better than adults; children aged five years have been given 0·4 or 0·5 c.c. of the usual strength of vaccine without suffering undue reactions. Most of us would prefer, however, to give only 0·1 or 0·2 c.c. to children of this age. It is always a good plan to give the inoculations late in the afternoon and, if possible, at the week-end. The writer of a recent editorial (*British Medical Journal*, 1940 (ii), 748), also suggests that the conventional doses of the ordinary vaccine (the only type of prophylactic we need now consider) might be reduced, if an effective response could be demonstrated by the available tests. It is probable that, after the primary course of injections, an occasional very small dose (e.g. 0·1 c.c.) would maintain satisfactory immunity; this procedure has already been tried and is worthy of further investigation. Another important point is that T.A.B. vaccine may be given during an epidemic without increasing the chances of infection, as was mentioned by Colonel H. J. Bensted (1940) in his recent Harben lectures.

Tetanus

A year ago I should have attached much more importance to tetanus prophylaxis. The incidence of tetanus in this war has, however, been negligible, much lower than in the War of 1914-18. In no case has tetanus been reported in wounded soldiers who had received protective inoculations of toxoid. Although active immunization may be indicated for A.R.P. workers, members of the Land Army, and others specially exposed to risk, mass immunization of the civilian population is not advised. This omission is not likely to have serious consequences provided that antitoxic serum can be given early to all wounded persons.

Miss D. M. Marvell and I have recently studied the titres of circulating antitoxin induced by tetanus toxoid in members of our laboratory staff (Marvell and Parish, 1940). One dose of tetanus toxoid gave very poor immunity, but two doses at an interval of six weeks induced useful amounts of circulating antitoxin. Wider spacing of the doses than six weeks gave better immunity, but this is usually inconvenient administratively. Women gave significantly higher titres than men; the men were not the sole individuals immunized with two doses.

In our paper we quote figures from the literature showing that boys aged 0—4 years are almost twice as susceptible to tetanus as girls of this age-group, and we therefore suggest that females have greater inborn resistance to this infection. This may be correlated with the greater response of females to immunization which has been observed in our investigation.

A third injection of 1·0 c.c. given after a long interval, e.g. seven to nine months, in our series, often produces a dramatic increase in circulating antitoxin, and more than counteracts any tendency of titres to drop below levels which might be considered safe. One year may be a more convenient interval for this "boosting" dose of toxoid.

Other Diseases

Time permits only brief reference to other diseases. With regard to *smallpox* we may have to pay dearly for our failure to make vaccination compulsory. Our native strains of variola are relatively mild, but the introduction of virulent strains from the Continent might tax the resources of our public health services.

Whooping-cough prophylaxis may be indicated for the individual, as the disease is so dread that any measure which may reduce its ravages even slightly should not be ignored. Perhaps with more knowledge of the vaccine and the best way to use it, we may have more confidence in recommending mass immunization. The need is there, but the large number of injections usually recommended is a deterrent to its widespread employment. Research is indicated on the use of fewer and smaller doses, wider spacing of the injections, and the effect of re-inoculation after one to two years with a minimal stimulus given subcutaneously or possibly by the nasal route. Methods of active immunization against the virus of *measles* are not sufficiently advanced to be worthy of serious consideration in the present emergency. *Scarlet fever* is relatively mild, and immunization with toxin too tedious and associated with too much reaction to be generally applicable; the value of active immunization for the staffs of hospitals is well known. The situation should be watched carefully, however, for this infection may take on a virulent phase, and we may have to revise our policy of ignoring specific prophylaxis. I have tried not to mention chemotherapy, but the great success which has attended its use in *cerebrospinal meningitis* has removed the necessity for serious consideration to be given to meningococcal vaccine.

Formol toxoid is effective in producing anti-*dysentery (Shiga)* serum in animals, and presumably an effective vaccine of this type could be made for human immunization (O'Brien, 1940). Research to this end is now in progress. The results obtained with *coryza* and mixed *influenza* (bacterial) vaccines are not very convincing when regard is paid to statistical considerations. Experiments are now being made to produce immunity in man by means of a mixed influenza virus and distemper virus vaccine.

Combined Immunization

Combined immunization has been in vogue for some years in the French Army, but one would hesitate to ask the British soldier to submit to compulsory inoculation with diphtheria and tetanus toxoids and T.A.B. vaccine. In deciding on any combination of antigens we should remember that diphtheria prophylactics occasionally cause reactions in older subjects, tetanus toxoid rarely does, and T.A.B. vaccine often gives rise to some soreness of arms and general symptoms. T.A.F. and tetanus toxoid might usefully be combined, and so might tetanus toxoid and T.A.B. vaccine. I am not very keen, however, on combined diphtheria prophylactic and T.A.B. vaccine for adults, for I am afraid some persons would have very severe reactions.

I have very little personal experience of combined antigens, although I am now immunizing members of the laboratory staff with diphtheria prophylactic, T.A.F., in conjunction with tetanus toxoid. The results now available indicate that titres of circulating antitoxin are at least as good after these combined antigens as after either antigen given separately. I think we should be careful about the combined use of A.P.T. and tetanus

toxoid, for the A.P.T. may go into solution in the toxoid, and its peculiar effectiveness, which depends on its insolubility in the tissues, may thus be destroyed.

Diphtheria prophylactic, A.P.T. and whooping-cough vaccine are a useful combination for children.

Sterilization of Syringes and Needles

Many sore arms which are ascribed to the prophylactic are really due to bacterial infection, and many published and private reports from British and foreign sources demonstrate the grave risk incurred if we do not trouble to sterilize our syringes and needles by heat. Far too many practitioners still rely exclusively on alcohol as a disinfectant, although its unreliability is well-known in the bacteriological laboratory.

As Bigger, Blacklock, and I (1940) have emphasized, one set of syringes and needles should be reserved solely for inoculations, and another complete set for the withdrawal of pathological fluids. A fresh sterile needle should be used for each injection. An intensive inoculation campaign should not be an excuse for slipshod methods.

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ABSTRACT.—If large-scale immunization of the general population of this country is to be carried out, then for reasons of urgency or for convenience, we must consider what combinations of antigens are effective, so that the number of injections is reduced to a minimum, e.g. how far may we combine (*a*) various bacterial vaccines, (*b*) bacterial vaccines and toxoids, (*c*) bacterial vaccines and virus vaccines, so as to obtain the best response to each antigen.

We have also to consider the best spacing of doses, as well as the great variation in individual response. It is remarkable that combining certain vaccines and toxoids actually greatly improves the response to the toxoid. Active immunization in the presence of an epidemic has been claimed by some to have cut short the epidemic, and provided the negative phase is avoided there appears to be good reason for recommending such a procedure. This may require an adjustment of the usual prophylactic dose. Slowly spreading epidemics may thus be successfully combated.

RÉSUMÉ.—Si l'immunisation de la population doit être pratiquée sur une grande échelle, il convient de se demander, dans l'intérêt de l'urgence ou de la commodité, quelles combinaisons d'antigènes sont effectives, pour que le nombre d'injections puisse être réduit au minimum. Par exemple, jusqu'à quel point peut-on combiner (*a*) les vaccins bactériens, (*b*) les vaccins bactériens avec les toxoïdes, (*c*) les vaccins bactériens et à virus, de façon à obtenir la meilleure réaction à chaque vaccin.

Il faut aussi considérer le meilleur intervalle entre les doses, ainsi que les grandes différences entre les réactions individuelles. C'est un fait remarquable que la combinaison de certains vaccins et toxoïdes améliore de beaucoup la réaction à la toxoïde. Certains auteurs affirment que l'immunisation active au cours d'une épidémie a coupé l'épidémie, et il semble raisonnable de recommander un tel procédé, pourvu qu'on évite une phase négative. Dans un tel cas il faudra peut-être modifier la dose de vaccin. De cette manière on pourrait combattre effectivement une épidémie à extension lente.

RESUMEN.—Si se debe efectuar una extensa inmunización de la población general de este país, habemos de considererar por motivo de urgencia o comodidad qué combinaciones de antígenos son eficaces para reducir al minimum el número de inyecciones, p.ej., hasta qué punto pueden asociarse (*a*) diversas vacunas bacteriales, (*b*) vacunas bacteriales y toxoides, (*c*) vacunas bacteriales y antivirus, de modo que obtengamos la óptima reacción a cada antígeno.

También habemos de considerar el mejor espaciar de las dosis, así como la gran variación de respuestas individuales. Es notable que la combinación de ciertas vacunas y toxoides mejora en efecto fuerte a la respuesta al toxoide. Algunos sostienen que la inmunización activa en presencia de una epidemia ha cortado la epidemia y con tal que se evite la fase negativa aparece buena razón de que recomiendamos dicho procedimiento. Esto puede necesitar un arreglo de la dosis profiláctica común. Se puede combatir así con buen éxito a las epidemias de lenta diseminación.

RESUMO.—Se a imunisação em larga escala da população geral deste paiz for executada, então por razão de urgencia ou por conveniencia, deve-se ver quaes as combinações de antigens que são eficazes de modo a reduzir ao minimo o numero de injeções;

por exemplo, até que ponto podemos combinar (*a*) varias vacinas bactériaes, (*b*) vacinas bactériaes e toxoides, (*c*) vacinas bactériaes e vacinas de virus, de forma a obter o melhor resultado para cada antigen.

Temos tambem de estudar o melhor modo de espaçar as doses, assim como a grande variedade nos resultados individuaes. É deveras notavel que combinando-se certas vacinas con toxoides, o resultado do toxoide é mais pronunciado. A imunisação activa durante uma epedemia, foi asseverado por alguns, ter debelado a epedemia, e uma vez que se evite a fase negativa, parece haver boas razões para recomendar tal procedimento. Isto pode exigir um ajuste na dose profilatica usual. As epedemias que alastrum lentamente podem ser assim combatidas com bom resultado.

THERE is the greatest need to-day for prophylaxis against the following groups of diseases: (*a*) Intestinal diseases resulting from contamination of food by sewage material, and from carriers; (*b*) droplet infections spread by overcrowding; (*c*) primary and secondary invasion of wounds by organisms. In these groups the following are of primary importance: (*a*) Enteric fevers; (*b*) diphtheria, whooping-cough, and influenza; (*c*) tetanus. Adequate chemotherapy has not yet been discovered for the treatment of any of these diseases, but fortunately efficient prophylactic agents are available, which will confer a high degree of protection.

Simultaneous Immunization against Various Infections

The use of mixed vaccines or antigens not only reduces the number of injections necessary, but saves much time and trouble both for the patient and the medical practitioner. The construction of the mixture should depend upon the particular group of the population to be immunized: e.g. a mixture of T.A.B. vaccine and tetanus toxoid is an appropriate combination for adult civilians and members of the Services in war-time, while a mixture of whooping-cough vaccine and diphtheria toxoid is especially suitable for young children at any time.

We must ask ourselves whether a combination of antigens given simultaneously in one injection is sound immunology, and also how far this multiplicity of antigens may be reasonably extended. Provided we use in our bacterial vaccines only recently isolated or virulent strains in which the recognized protective antigens are dominant, we can obtain good immunization against all the members of a bacterial vaccine mixture.

Combination of Bacterial Antigens

The idea of combining a number of different vaccines or antigens is not new. It was in 1916 that immunization against the paratyphoid fevers simultaneously with typhoid was introduced into the Army, with the result that the simple anti-typhoid vaccine disappeared and T.A.B. (typhoid, paratyphoid A and B) vaccine appeared. Even before that mixed vaccines had been extensively used for the treatment of respiratory catarrhs. In this country we normally need only *B. typhosus* and *B. paratyphosus* B in our vaccine, but when our troops return from abroad there are likely to be carriers of *B. paratyphosus* A and *B. choleræ* in their midst, and so it is advisable to include these organisms in our vaccine.

A healthy person does respond simultaneously to a great many antigens, developing antibodies to each individual organism. When a large group of people were simultaneously injected with a mixture of five different vaccines, I found that there was adequate response to all components of the mixture, viz. *B. typhosus*, *B. paratyphosus* A, *B. paratyphosus* B, *B. choleræ*, and tetanus toxoid. Thus there is little competition in the body between bacterial antigens when several are used together in a mixed vaccine, and in prophylaxis the practitioner may be required to make his own combinations to meet the particular conditions which may arise.

Combination of Bacterial Toxoids

A more accurate estimation of the degree of immunity can be obtained when a combination of bacterial toxoids is used. The antigenic response can be determined either by a skin test or by the accurate measurement of the circulating antitoxin. Glenny's (1925) experience with horses causes us to wonder whether the wholesale mixing of toxoids does not put too much strain on the immunity mechanism. He attempted to immunize horses against three well-known toxins, viz. those of *B. tetani*, *Vibrion septique*, and *Cl. welchii*. When a horse received only one of the above antigens the response was good, being 1,000, 10,000, and 5,000 units per c.c. respectively; but with the horses

which received all three toxins the best titre obtained to each of these three toxins was only 500, 3,000, and 1,000 units per c.c. respectively. Glenny, however, was attempting to manufacture hyperimmune serum for use in passive immunity, and was thus seeking a much higher degree of antibody production than is required in man. It would seem that more experiments in man must be undertaken before we can recommend the simultaneous administration of a multiplicity of toxoids with absolute confidence. Nevertheless, Ramon's successful immunization with combined tetanus and diphtheria toxoids suggests that the use of mixtures of toxoids may be usefully extended.

Combination of a Bacterial Vaccine and a Toxoid

Not only can it be shown that the mixing of a bacterial vaccine and a toxoid does not impair the response to both types of antigen, but we have definite proof that in some cases the combination of a bacterial vaccine and a toxoid will enhance the response to the toxoid. This was first recognized by Ramon (1939) who summarized the results of several years investigation in his article. He used combinations of T.A.B. vaccine and tetanus toxoid, and T.A.B. vaccine and diphtheria toxoid. More recently, these combinations have been further investigated by Holt and myself (1940); we showed that the response to tetanus toxoid in man was five time greater if combined with T.A.B. vaccine than when the same tetanus toxoid was used alone; and also that the response to the T.A.B. vaccine in vaccine-toxoid mixture was not interfered with, in spite of the interval between the two doses being increased from ten days to twenty-eight days or more. Similar results have been obtained by Schutze (1940) in the combination of whooping-cough vaccine and diphtheria toxoid in animals. He showed that the response to the toxoid (as judged by the Schick test) was better with the combination than with the toxoid alone. Moreover, the combination did not weaken the antigenic response to the vaccine. More recently, Dr. Culver Evans and I have immunized a series of children with the combination of whooping-cough vaccine and diphtheria toxoid (A.P.T.), and in every case the children tested showed a good response to both vaccine and toxoid. Owing to evacuation only 32 out of 170 children were Schick tested, and all were negative three months after the last inoculation. Twenty-two children who were old enough were also tested for their response to the vaccine. All showed an adequate response in the formation of agglutinins against *B. pertussis*, and all except four had strongly positive complement fixation for *B. pertussis*. The response to the toxoid could not be better, and the response to the vaccine is at least as good as in a similar series of children who received vaccine alone. As far as we know, none of these children has since been exposed to either diphtheria or whooping-cough, and so it is better to withhold the details of this experiment until a later date, when the laboratory tests for immunity may be confirmed by clinical results. However, there is sufficient evidence of a possible immunity to recommend a more extended trial of this particular combination of vaccine and toxoid.

Ramon and his colleagues obtained a negative Schick test in every child in a large group immunized with a combined T.A.B. vaccine and diphtheria toxoid, but they give no exact figures. Their results are remarkable, as we expect to get some failures even if our most active diphtheria prophylactic is used, i.e. two properly spread doses of A.P.T. In normal times there is no reason for combining T.A.B. vaccine and A.P.T.; it is more reasonable to combine the toxoid with whooping-cough vaccine. In future we should consider the advisability of "boosting" the immunity of the persistently Schick-positive child by a combination of A.P.T. and whooping-cough vaccine. It would serve a double purpose, and protect against two diseases common in childhood.

The Combination of a Bacterial Vaccine and a Virus Vaccine

My experience of this combination is limited to influenza virus vaccine and its associated bacteria. There are some pure virus diseases, and some such as those spread by droplet infection, where there is an associated bacterial infection which may increase greatly the severity of the disease and its complications. The killing epidemic of influenza in 1918 may now be considered to have been caused by a filtrable virus and associated bacteria such as the *B. influenza* of Pfeiffer, which was by far the commonest organism found. However, it was during this pandemic that bacteriologists began to doubt seriously that this bacillus caused the primary infection. Smith, Andrewes, and Laidlaw (1933), definitely established the virus as the primary infective agent, and Shope (1931), discovered that swine influenza, which appeared in America following the 1918

pandemic of influenza in man, was due to a combined infection of a virus and a bacillus almost identical with those found in epidemic influenza in man. If he infected the pigs with the virus a transient fever resulted and the pigs recovered; if he infected them with a culture of the bacillus, infection was neither constant nor severe; but when he infected both virus and bacillus, typical swine influenza resulted and the animals died with pneumonia (1937). On the other hand complete protection against subsequent infections of the combined virus-bacterial mixture was obtained only in those pigs which had recovered from a previous virus infection, but those animals inoculated with vaccines of the bacillus had acquired some immunity although it was not so complete as the immunity produced by the virus infection.

The possibility of inoculating against epidemic influenza is of recurring importance. Some attempts have been made to immunize man with a killed vaccine of the influenza virus, but conclusive proof of its efficiency has not yet been obtained because the opportunity of a clinical test has not arisen. Attempts were made in 1918-19 to immunize men against influenza by means of vaccines of the bacterial element of the infection, and many papers appeared (notably one by Sir William Leishman) indicating that these were of value. Although large numbers of workers were convinced that immunization with these bacterial vaccines diminished the incidence, and especially the severity of the disease, none of the published figures have satisfied the statisticians.

In conjunction with Dr. Himmelweit I made some observations to see whether a vaccine of the influenza virus could be combined with a bacterial vaccine. The response to the virus vaccine, as shown by the presence of protective antibodies in the human serum for mice was not impaired, and there is no reason to believe that the usual response to the bacterial vaccine was not obtained. Therefore there is nothing to be lost by combining the virus and the bacterial vaccines, although it may be more scientific to proceed with the virus vaccine alone until its value has definitely been assessed in man; but in war, where every day lost in illness is important, it is probably wiser to use the combined virus-bacterial vaccine.

Inoculation in the Presence of an Epidemic

As to the wisdom of inoculating in the presence of an epidemic there appears to be a difference of opinion in this country. Most of our knowledge has been acquired in countries where enteric fevers are endemic, and where epidemics spontaneously arise. At the time of the Croydon epidemic of typhoid fever in 1937, there was much correspondence in the medical press about this matter. There are obvious advantages in inoculating the people at risk, but the fear of producing a serious accident associated with a negative phase in the inoculated was suggested as a grave disadvantage. This question of a negative phase is a bogey which has worried us too long. In prophylaxis a negative phase is rarely produced with a healthy patient. This is different from the negative phase demonstrated by Wright and his school, in therapeutic inoculation.

Vaughan (1941) showed that in a recent epidemic one person in six of the contacts of a case of paratyphoid fever had positive fæcal or urinary cultures. If this represents the usual spread of infection among healthy contacts, it is remarkable that no serious accidents occur if we inoculate in the presence of an epidemic. My own experience has led me to disregard the danger of a negative phase in healthy persons in the presence of an epidemic. In Cyprus in an epidemic of cerebrospinal fever I made many hundreds of inoculations at the focus of the epidemic without accident. It has been my practice for fifteen years to inoculate immediately all contacts of a case of enteric fever—nurses, relatives, &c., with a dose of 50 millions of the infecting organism. This is followed by similar doses of 50 millions for the next two weeks. No accidents have occurred in the inoculated people.

Dr. Dax has allowed me to relate his experience in a recent epidemic of paratyphoid B fever. An epidemic of this disease occurred in a mental hospital, and was only arrested after he had inoculated all the rest of the inhabitants with three doses of 0·2, 0·5, and 1·0 c.c. of T.A.B. at weekly intervals. I have been told that in the colonies, and in the large commercial companies abroad it is their confirmed opinion that they should inoculate if an epidemic threatens. However, there is some evidence that the full prophylactic dose is not necessary to protect for a short period, and as the negative phase is so ingrained in the minds of many medical practitioners, it might be advisable to recommend a smaller dose, say, one-fourth of the usual prophylactic dose.

With droplet infection, such as influenza, we have a shorter incubation period, and

a more direct method of spread, and consequently the rise of the epidemic is much more rapid. Immunization of the focus of epidemic infection will probably do very little good, but mass inoculation in the probable paths of spread may cut short the epidemic.

The Individual Response to an Antigen

Experimental pathologists are well acquainted with this difference in the individual response to an antigen, but its significance does not seem to be appreciated by the clinicians and epidemiologists. We in the laboratories sometimes feel that the clinicians demand too much from a particular antigen. For example, they demand 100% protection from a prophylactic course, whereas in animal experiments we have been led to expect up to 10% of failures. Where we immunized with the same toxoid a set of healthy adults of similar age and sex who have lived very similar lives, we find that they vary greatly in their response to tetanus toxoid. 20% responded at least twenty times as well as the minority and two to five times as well as the average. Fleming and Maclean (1936) have shown similar results in staphylococcal infection where the response to the same dose of toxoid produced in the patients antitoxic values varying from 2 units to 10 units. In every prophylactic experiment there are always a few who appear to make no immune response to the antigens administered. In numerous such experiments our experience shows that about 10% of humans will be poor responders, 70% will be average responders, and 20% will be good responders. Also we find that poor responders to one antigen are poor responders to other antigens and vice versa. Unfortunately, we have not sufficient experience to convert this variation in the individual response to bacterial antigens into terms of susceptibility to infection. Nevertheless, it raises an important question in public health, for known poor responders should be given a specialized course of immunization.

With regard to these poor responders, we have shown above that the response to toxoids is greatly increased by combining them with an irritative agent such as T.A.B. or whooping-cough vaccine. There is also some evidence to show that increasing the interval between doses of a bacterial vaccine (as has already been done in toxoid immunization) produces a better secondary response to subsequent inoculation. It may be that further experience in man will lead us to increase the customary interval between the doses in prophylactic courses and so produce a greater and more lasting result.

It is to be hoped that the lead given by the Ministry of Health in stimulating the medical profession to encourage extensive immunization against diphtheria during this war has won the confidence of the general public and overcome that apathy which has made us lag behind other nations in the prevention and elimination of infectious diseases.

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Section of Medicine

President—Sir Maurice Cassidy, K.C.V.O., M.D.

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DISCUSSION ON THE THERAPEUTIC VALUE OF TRANSFUSION OF DERIVATIVES OF BLOOD

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Abstract.—Transfusion may be performed for a large number of reasons which must be clearly defined because almost all derivatives of blood lack one or more of properties of fresh blood and have, therefore, only a limited therapeutic value. The convenience of blood derivatives must not lead to improper use. War has led to the development of durable blood derivatives suitable for the blood volume restoration essential for the treatment of secondary shock. Stored blood over a certain age must be included in this category.

Experimental evaluation has placed the order of preferment for blood derivatives used for blood volume restoration as citrated plasma, serum, hæmoglobin-Ringer, gum saline, red cells in saline suspension, isotonic saline and glucose. Clinical evaluation of the advantages of plasma over serum and vice versa has not yet been fully decided. Serum preparation, dry or fluid, is technically much easier than plasma. For blood volume restoration in secondary shock there is required an innocuous protein fluid which is retained in the circulation. The amount that needs to be transfused is often incredibly large and must be at least 50% of the volume lost; the effect requires to be carefully controlled by blood-pressure observations and clinical judgment. Rate also is important. Extensive experience has shown that though citrated plasma is eminently satisfactory it is an advantage to use a proportion of blood when the volume restoration needs to be large.

Résumé.—La transfusion de sang est nécessitée par un grand nombre de causes qu'il faut bien définir, car la valeur thérapeutique de presque tous les dérivés du sang est limitée par le fait qu'une ou plusieurs des qualités du sang frais leur manquent. La commodité des dérivés du sang ne doit pas mener à leur emploi incorrect. La guerre a amené l'évolution de dérivés durables appropriés à la restauration du volume du sang, qui est essentielle dans le traitement du choc secondaire. Le sang préservé pendant plus d'une certaine période doit être inclu dans cette catégorie.

L'évaluation expérimentale de ces dérivés employés pour la restauration du volume du sang permet de les classifier dans l'ordre de préférence suivant: plasma citraté, sérum, hémoglobine-Ringer, solution saline de gomme, suspension de globules rouges dans une solution saline, solution de sel isotonique avec glucose. En clinique les avantages du plasma sur le sérum et vice-versa n'ont pas encore été décidés. La préparation du sérum desseché ou liquide est beaucoup plus facile que celle du plasma. Pour restaurer le volume du sang dans le choc secondaire il faut une solution protéinique inoffensive, qui est retenue dans la circulation. La quantité nécessaire est souvent énorme, et doit égaler au moins 50% du sang perdu. Le résultat doit être soigneusement contrôlé par des observations de pression sanguine et par le jugement clinique. La rapidité de la transfusion est aussi importante. Une large expérience a démontré que quoique le plasma citraté soit parfaitement satisfaisant, il est avantageux d'employer une certaine proportion de sang dans les cas où un grand volume de sang doit être remplacé.

Resumen.—Se efectúa la transfusión por varias razones que habemos de fijar claramente, porque casi todos derivados sanguíneos carecen de unas cuantas propiedades de la sangre fresca, y por eso poseen solamente un valor terapéutico restricto. No debe llevar a un empleo impropio lo de la comodidad de los derivados sanguíneos. La guerra ha conducido al desarollo de derivados sanguíneos duraderos, apropiados para reponer el volumen de sangre esencial en el tratamiento de choque secundario. Hay que incluir en esta categoría sangre conservada que excede una vejez determinada.

La evaluación experimental ha puesto en el orden de preferencia siguiente los derivados sanguíneos empleados por reponer el volumen de sangre: plasma citrado,

suero, hemoglobina Ringer, goma salina, glóbulos rojos en suspensión salina, salina isotónica, y glucosa. El evaluar clínicamente las ventajas del plasma sobre el suero y viceversa aun no está acabado. Los preparados de suero, secos o líquidos, se manejan mucho más fácilmente que el plasma. El reponer el volumen de sangre en choque secundario demanda un fluído proteínico innocuo que quede en circulación. La cantidad que ha de transfusarse está a menudo increíblemente grande, y tiene que alcanzar al menos a un 50% del volumen perdido; el resultado es de controlar rigurosamente por observaciones de la tensión y por juicio clínico. También es importante la velocidad. De una experiencia ancha se verifica el que aunque sea muy satisfactorio el plasma citrado hay ventaja en usar de una proporción de sangre cuando debe ser grande el reponer el volumen.

RESUMO.—A transfusão pode ser feita por muitas razões que deven ser atentamente especificadas, porque a quasi todos os derivativos do sangue faltam uma ou mais das propriedades do sangue fresco, e teem portanto somente um valor limitado.

A conveniencia dos derivativos do sangue não deve levar a abusos. A guerra instigou o desenvolvimento dos derivativos duraveis do sangue, apropriados para a restauração do volume do sangue, que é essencial, para o tratamento do choque secundario.

O sangue guardado álem de um certo tempo deve ser incluido nesta categoria.

A avaliação experimental estableceu a ordem de preferencia para os derivativos do sangue usados para a restauração do volume do sangue, como plasma citratado, sôro, hemoglobolina-Ringer, goma salina, celulas vermelhas numa suspensão salina, isotonico salino e glucose.

O valor clinico das vantagens do plasma sobre o sôro e vice versa ainda não está decidido. A preparação do sôro, sêco ou liquido, é tecnicamente mais facil do que o plasma. Para a restauração do volume do sangue no choque secundario é preciso uma proteina fluida inofensiva, que seja retida na circulação. A quantidade que é preciso transfundir é frequentemente incrivelmente grande e deve ser pelo menos 50% do volume perdido; o efeito deve ser controlado cuidadosamente pelas observações da tenção arterial e pelo criterio do clinico. A proporção tambem é importante. A larga experiencia tem mostrado que apesar do plasma citratado ser extremamente satisfactorio, é vantajoso usar uma proporção de sangue, quando o volume da restauração é grande.

IN introducing this subject our thoughts are naturally focused on the conditions of secondary shock and severe hæmorrhage which are peculiarly prominent during this time of war and which indeed have been the main stimulus to research for the production of durable blood substitutes or blood derivatives. This is because the red cells of blood have only a limited life even with the most precise methods of storage and it is essential to have ready for an emergency large stores of transfusion fluid. Despite the acknowledged importance of war requirements it is nevertheless necessary to take a longer view, to recognize the limitations of blood derivatives, and to realize that the products suitable for the peculiar conditions of war are more often than not quite unsuitable for the requirements of civil practice. The summoning of a donor and the taking of fresh blood for an individual case is often highly inconvenient and always laborious. The convenience of the blood bank, or stores of other products, obtained at relative leisure is so great that it is a temptation for convenience to outweigh the therapeutic ideal.

Transfusion should always be performed with a definite object. It is necessary to have this object clearly in mind and to know whether the various derivatives of blood will fulfil the requirements. Transfusion is practised for two main reasons. These are, restoration of oxygen-carrying capacity, as in anæmias, for which red corpuscles are essential, and, restoration of blood volume, for which any innocuous fluid which is well retained in the circulation is suitable. In addition to these two main reasons, on relatively rare occasions transfusion is practised with a view to contributing leucocytes as in agranulocytosis, with a view to contributing platelets or other clotting elements as in essential thrombocytopenia and other hæmorrhagic diatheses, and, for immunological purposes to contribute, in cases of infection, either complement or specific antibodies or sometimes, vaguely, as a general tonic.

As a general rule it may be stated that derivatives of blood, and in this category I am taking the liberty of expanding the title of this discussion to include stored blood more than a few days' old, are extremely efficient for purposes of blood volume restoration but are, with the exception of stored blood, quite useless for increasing oxygen-carrying capacity or, including stored blood, quite useless for contributing leucocytes, clotting factors and immune bodies, specific or non-specific. For these last three factors fresh blood should always be used.

The derivatives of blood available for use are stored blood of different ages, citrated

plasma, blood-serum, dried blood-serum which can be reconstituted at normal, double or quadruple strength, and concentrated suspensions of red cells in a minimum of physiological glucose saline or plasma.

With regard to stored blood very much depends upon its age. Blood a few days old cleanly and properly taken is about as good as fresh blood for restoration of oxygen-carrying power and is obviously efficient for blood volume restoration. The corpuscles of such young blood are also sufficiently durable to allow of their decantation and resuspension in physiological saline or glucose saline in high concentration. But as time goes on the corpuscles of stored blood deteriorate so that more and more of the corpuscles become fragile and eventually hæmolyse. These fragile corpuscles do not endure in the circulation of the recipient. Their survival time is a function of their fragility. Old blood containing much free pigment and vast numbers of fragile cells produces a reaction accompanied by jaundice because of the foreign pigments; such blood obviously contributes only temporarily to oxygen-carrying power. Such blood also is clearly unsuitable for the treatment of aplastic and other anæmias where the maximum durability of the transfused corpuscles is desired. Yet even aged and ageing blood has its therapeutic use if the physician is prepared to take a chance. It was a trick known to the French physicians long before the war as a method of introducing iron by the parenteral route. To those obstinate cases of iron-deficient anæmias, usually in females, unable to take iron by the mouth because of metallic taste, gastric upset, giddiness and other symptoms, these bold Frenchmen would prescribe a transfusion of oldish blood, they would even name a vintage in days to produce a tolerable reaction and leave the reticulo-endothelial system to break up the fragile cells, phagocyte the store of iron for red cell building purposes, what time the unwanted iron-free pigment was excreted. What mattered it if the patient became jaundiced, the iron had been introduced and the result achieved? And so when it comes to battle casualties if blood volume is restored with somewhat old blood we know that jaundice in the recipient is, in contrast to civil practice, unlikely to be a case for a law suit, and the stores of internal iron so introduced will help many an exsanguinated man to recover his hæmoglobin during convalescence. I am not specifically advocating the use of old blood as a routine but I put this point of view forward to show that in a war emergency a bottle of even old blood has its uses. We know that carefully taken and refrigerated blood to which glucose has been added does not develop serious fragile properties for at least four weeks. Such stored blood has excellent volume-restoring properties as well as reasonably durable oxygen-carrying power. In the Dunkirk campaign one of the officers of my Service administered stored blood seven weeks old with, as he reported, "excellent results".

Stored blood then has a double value except when it is so aged that a dangerous hæmolytic reaction is bound to occur. It can be used for volume-restoring purposes; up to three to four weeks it has quite a good oxygen-carrying power and when under a week old this property can be regarded as almost the equivalent of fresh blood; the younger the blood the more its durability. The disadvantage is the complexity of the apparatus required for its proper preservation. On the other hand, leucocytes perish within a few hours, clotting elements deteriorate within a few days, whilst immune bodies and complement slowly decline.

The corpuscles of young stored blood and of fresh blood are available for the preparation of concentrated red cell suspensions for the treatment of anæmia where the object is to provide the maximum increase in oxygen-carrying power rather than blood volume increase; the latter indeed may be a disadvantage in those whose heart muscle has been enfeebled by a long-standing anæmia. Such concentrated suspensions allow of an increase of hæmoglobin of approximately 20% per pint instead of the 10% anticipated with an ordinary transfusion. To my mind such suspensions are best made from fresh cells in order that the maximum durability of the corpuscles may be obtained. The cells of under a week old are quite usable. My personal experience of this method is limited to some six cases in the course of which the results have been excellent in agreement with the published work of MacQuaide and Mollison (1940). The procedure is particularly advantageous in those with true aplastic anæmia who have to lead a transfusion life and in whom it greatly reduces the time taken for a transfusion. Such suspensions have, however, a very poor volume-restoring power as judged by experimental results.

As to other derivatives of blood, I am able firstly to quote the experimental animal work of two of my Army colleagues, Major Buttle and Captain Kekwick (1940), carried out in conjunction with Dr. Schweitzer of the Middlesex Hospital Physiological Department, which work was performed to give an indication as to the best blood derivatives for

resuscitation work to produce in the large amounts required by the Army. The experimental survey was carried out with a standard technique which, in a given time, removed an amount of blood sufficient to reduce blood-pressure to a level from which recovery was not possible unless reasonable blood-volume restoration was made. Fluid replacement to the extent of five-sixths of the blood removed was carried out. From these results the order of preference of the various fluids tried was whole blood, plasma, serum, hæmoglobin-Ringer, gum saline, isotonic saline, isotonic glucose. (This for the particular purpose of resuscitation from secondary shock which to me is synonymous with blood-volume restoration.)

In speaking of plasma one has to be specific concerning its composition. The protein content is the only true index of efficiency because all crystalloids such as the citrate content or added saline diluent are rapidly excreted and only restore blood volume temporarily. Such observations as I make refer to the plasma produced by my Service which has a protein content of 4 to 5% and a plasma content of 5 parts in 7. Animal experiments show that diluted saline plasma, to which 50% of saline is added to the already citrate diluted plasma, is a relatively poor product for resuscitation work. The making of a clear, sterile, filtered, citrate plasma on a large scale has been beset with technical difficulties, many of which are not encountered when dealing with serum, but these have been almost completely overcome.

My closing remarks are concerned mainly with sterile, filtered, citrate plasma with a protein content of 4 to 5% when used for the blood-volume restoration essential for the successful treatment of secondary shock. I must leave to other speakers to tell of experience which I have not had with serum and reconstituted serum. Nor can I say whether the incidence of reactions in human beings with serum and its products is as high as was found in the experimental animal. One should note, however, that Brown and Mollison had a very high incidence of reactions with concentrated solutions of reconstituted serum.

Concerning citrate plasma, or serum for that matter, both are recognized as being more physiological fluids for blood-volume restoration than is blood, in cases where the loss to the circulation is due to plasma and so gives rise to hæmoconcentration. The classical example is burns. In the treatment of six cases of burns citrated plasma has been satisfactory.

During the course of treating over one hundred air-raid casualties we have had opportunity to use 165 pints of plasma; three cases only have exhibited mild and transient rigors; the plasma has been from ten to fifty-six days old, stored at room temperature and in the dark. The maximum administered to any one case has been six pints and in relation to this we have concluded that when large transfusions are needed it is an advantage for at least one pint in three to be blood. It should be noted that Army citrate plasma contains no merthiolate preservative so that toxicity from this antiseptic is not met with.

In a complete and systematic study of twenty-four air-raid casualties the efficiency of citrate plasma when used for reasonable quantitative replacement of blood loss has been unequivocal. It is essential for the quantitative nature of the replacement to be controlled by serial blood-pressure examinations and it is an advantage when accurate assessment is desired if the simple blood-volume calculation for which plasma transfusion gives opportunity can be incorporated in the observations in order to check the sufficiency of restoration from two aspects. If there is to be any proper assessment of the relative merits of plasma and serum then cases that have suffered comparable blood loss and comparable reduction in blood-pressure must be systematically studied throughout the course of the transfusions. Without these observations no one can say whether blood-volume restoration has been adequate or excessive. In presenting the facts from three cases selected from among the twenty-four studied (Kekwick *et al.*, 1941), I would emphasize the almost unbelievable amount of blood loss which some casualties suffer and still remain alive, the quantitative recovery of blood-pressure as blood volume is restored (it amounts to 10 to 20 mm.Hg per pint bottle), the necessity for the replacement to be of the order of not less than 50% of blood loss and, for permanent effect, the importance of considering only the protein fraction of the transfused fluid in accordance with the experimental results of Magladery, Best and Solandt (1940), which necessitated not less than a 40% replacement of protein. Our experience has also shown that the need for transfusion, at least in serious cases, rarely ends in the resuscitation ward. The anæsthetic or operation, especially if accompanied by further blood loss, may cause a rapid deterioration in condition which needs to be instantly countered. In preparation for this it is a good practice to send the resuscitated patient to the theatre with a cannula tied in place

and a bottle of slowly dripping blood, which can be speeded up instantly should the necessity arise.

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RESUSCITATION WARD RECORDS OF AIR-RAID CASUALTIES (EXCLUDING FURTHER TRANSFUSIONS REQUIRED IN OPERATING THEATRES).

	1	2	3
Calculated blood loss (c.cm.)	3,500	1,600	3,000
Total fluid administered (c.cm.)	2,160	1,620	1,620
Protein fraction (c.cm.)	1,540	1,155	1,155
Per cent. of total lost fluid replaced	62	100	54
Blood-pressures:			
Initial	Unrecordable	50/35	50/35
After 1st pint	40/Unrec'dble	70/50	80/45
After 2nd pint	60/40	85/55	95/60
After 3rd pint	80/50	105/65	115/70
After 4th pint	105/55	—	—

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ABSTRACT.—The results obtained at the North West London Blood Supply Depot with certain blood derivatives are analysed, namely, plasma, serum, and concentrated red cells. It is emphasized that the observations made are necessarily qualitative rather than quantitative, since air-raid casualties are rarely suitable for accurate controlled studies.

Plasma and serum.—Both filtered and unfiltered plasma with an approximate protein content of 4 to 5% have been available for clinical trial. Reconstituted dried serum and filtered serum have also been tested, the latter with a protein content of 7%, the protein of the former being dependent upon the concentration at which it was given.

Toxicity.—There appeared to be no marked difference in the reaction rates obtained with plasma, normal concentrated serum and whole blood. Slightly higher reaction rates were observed with four times concentrated serum, but the type of reaction was extremely mild.

Relative therapeutic value.—Plasma, serum and blood appeared equally effective in the treatment of patients with "shock". Since some degree of anæmia has frequently been found in air-raid casualties, it is probable that the best results will be obtained with the administration of both blood and a protein fluid to such patients. In the case of burns, when hæmoconcentration occurs, plasma or serum are definitely to be preferred to blood in the first twenty-four hours. Local œdema may be reduced by the use of concentrated serum. In the presence of severe sepsis fresh blood should be given. Concentrated serum has proved disappointing in the treatment of nephrotic œdema.

Relative dosage.—No great difference in the dosage of blood, serum and plasma has been noted.

Dried serum has the following additional advantages: (1) It does not clot, (2) it is not readily infected, (3) it is unaffected by temperature, (4) it has a small bulk.

Concentrated red cells have proved valuable in the treatment of conditions in which it is necessary to raise the hæmoglobin without greatly increasing the blood volume, namely, anæmia in elderly subjects requiring operation, and in anæmia of sepsis.

RÉSUMÉ.—Analyse des résultats obtenus au North West London Blood Supply Depot par l'emploi de certains dérivés du sang, c'est-à-dire le plasma, le sérum et les globules rouges concentrés. Les observations faites sont qualitatives plutôt que quantitatives, car les victimes d'attaques aériennes sont rarement des sujets adaptés à des études exactes contrôlées.

Plasma et sérum.—Des plasmas filtrés et non filtrés, contenant de 4 à 5 pour cent de protéine ont été disponibles pour des essais cliniques. Des expériences ont aussi été faites avec du sérum desseché reconstitué et du sérum filtré, ce dernier contenant 7% de protéine. Le taux de protéine dans le sérum desseché dépend de la concentration à laquelle on l'emploie.

Toxicité.—La différence entre la fréquence des réactions produites par le plasma, le sérum normal concentré et le sang total ne semble pas être grande. La proportion de réactions a été un peu plus haute après l'emploi de sérum à quadruple concentration, mais ces réactions ont été trés faibles.

Valeur thérapeutique relative.—Le plasma, le sérum et le sang ont paru également utiles dans le traitement du " choc ". Comme un certain degré d'anémie a souvent été découvert chez les victimes d'attaques aériennes, il est probable que les meilleurs résultats seront obtenus par l'administration de sang et d'un liquide protéinique ensemble. En cas de brûlures, où le sang est concentré, le plasma ou le sérum sont certainement préférables au sang pendant les premières vingt-quatre heures. L'oedème local peut être diminué par l'emploi de sérum concentré. En cas de septicémie grave il faut donner du sang frais. Le sérum concentré a donné des résultats décevants dans le traitement des oedèmes néphrotiques.

Dosage relatif.—Aucune différence importante n'a été notée entre les dosages du sang, du sérum et du plasma.

Le sérum a en outre les avantages suivants : (1) il ne se coagule pas, (2) il ne s'infecte pas facilement, (3) la température ne l'altère pas, (4) son volume est petit.

RESUMEN.—Se analizan los resultados que se obtuvieron en el Centro de conservación y distribución de sangre del noroeste de Londres con algunos derivados sanguíneos, a saber el plasma, el suero y los glóbulos rojos concentrados. Han de estar cualicativas más que cuantitativas las observaciones hechas, puesto que rara vez favorecen a investigaciones exactas y controladas los accidentados de ataques aéreos.

Plasma y suero.—Eraban aprovechables para investigaciones clínicas tanto el plasma filtrado como el no filtrado, con un contenido proteínico aproximado de 4 a 5%. También se probó el suero desecado reconstituido y el suero filtrado, éste con un contenido proteínico de 7%, aquél viendo proporcionarse su porcentaje de proteína a la concentración que se administraba.

Toxicidad.—Ninguna diferencia marcada se notó entre las tasas de reacción del plasma, del suero concentrado normal, y de la sangre íntegra. Se observaron tasas de reacción un poco más altas con el suero cuatro veces concentrado, pero fué la reacción de tipo muy blando.

Valor terapéutico comparado.—El plasma, el suero y la sangre parecían igualmente efectivos en el tratamiento de enfermos que padecían de " choque ". Puesto que se encontra a menudo alguna anemia en los accidentados de ataques aéreos, es probable que se obtendrán aquí los mejores resultados por la administración de sangre y de un flúido proteínico. En las quemaduras, cuando ocurre la hemoconcentración, se prefiere a la sangre en las 24 primeras horas o el plasma o el suero. La edema local se reducirá en utilizando suero concentrado. Donde hay sepsis grave debería darse sangre fresca. El suero concentrado se probó desengañoso en el tratamiento de edema nefrótica.

Dosificación relativa.—No se notó gran diferencia entre las dosis de sangre, suero y plasma.

El suero desecado posee también las ventajas siguientes : (1) No se coagula. (2) No fácilmente se infecta. (3) La temperatura no lo modifica. (4) Es de pequeño volumen.

Glóbulos rojos concentrados resultaron preciosos en el tratamiento de condiciones en que es necesario realzar la hemoglobina sin aumentar demasiado el volumen de sangre, a saber en la anemia de viejos que necesitan intervención cirúrgica, y en la anemia de sepsis.

RESUMO.—Os resultados obtidos no Centro para Fornecimento de Sangue, no Norueste de Londres, com certos derivativos do sangue analisados, a saber, o plasma, o sôro e as celulas vermelhas concentradas. Deve-se ter em conta que as observações feitas são necessariamente mais qualitativas que quantitativas pela razão das casualidades das incursões aereas serem raramente apropriadas para estudos controlados de confiança.

Plasma e sôro.—O plasma tanto filtrado, como não filtrado com um conteudo de proteina de cerca de 4 a 5% foi usado para uma experiencia clinica. Tambem foram feitas experiencias com sôro seco reconstituido e sôro filtrado, este ultimo com um conteudo de 7% de proteina, estando a proteina do primeiro dependente da concentração em que foi deita.

Poder toxico.—Parece não haver diferença nos resultados de reação obtidos com plasma, sôro normal concentrado e sangue. Resultados de reação um pouco mais elevados foram notados com sôro concentrado 4 veses, mas o tipo da reação foi extremamente fraco.

Valor terapeutico relativo.—O plasma, o sôro, e a sangue parecem egualmente eficases no tratamento dos doentes con " choque ". Como se tem encontrado um certo grau de anemia nas pessoas atingidas nas incursões aereas, é provavel que se possam obter os melhores resultados com o emprego, tanto de sangue como de proteina fluida nestes doentes. No caso de aparecerem queimaduras, quando ha hæmoconcentração, plasma ou sôro devem certamente ser preferidos ao sangue nas primeiras 24 horas. O edema local pode ser combatido com o uso de sôro concentrado. Em caso de infeção setica severa deve-se administrar sangue fresco. O sôro concentrado não tem dado o resultado desejado no tratamento do edema nefrotico.

Dosagem relativa.—Não se tem notado grande diferença na dosagem do sangue, do sôro e plasma.

O sôro seco tem as seguintes vantagens: (1) Não coagula, (2) não é facilmente infetado, (3) não é afetado pela temperatura, (4) tem volume reduzido.

As celulas vermelhas concentradas teem provado o seu valor no tratamento dos casos em que é preciso aumentar a hemoglobina sem aumentar o volume do sangue sensivelmente, como acontece nos casos de anemia das pessoas de edade precisando serem operadas, e na anemia provocada pela infeção setica.

In the last year we have had available for transfusion certain blood derivatives in addition to whole blood itself, namely plasma, serum and concentrated red cells. Plasma and serum are of theoretical value particularly in those conditions in which there is a reduction in blood volume, or in circulating plasma protein. Concentrated red cells are useful in patients in whom it is necessary to raise the hæmoglobin without unduly increasing the blood volume.

The object of the present communication is to summarize the evidence that has been obtained at the N.W. London Blood Supply Depot as to the clinical use of these substances. We are indebted to our colleagues at the depot for permission to make use of the data they have collected and to the ready collaboration of many transfusion officers.

Plasma and Serum

In discussing the use of serum and plasma three questions arise. First, are these derivatives more or less liable to cause reactions than blood? Second, what is their relative therapeutic value? Third, what is the dosage in which they should be employed? If no difference can be detected between their toxicity and dosage, certain other considerations, such as relative ease of preparation, storage and transport, may be considered.

Plasma may be prepared in three different forms: unfiltered, filtered and dried. Unfiltered plasma is obtained by syphoning the supernatant fluid off the red cells after sedimentation has occurred, or by centrifugalization. It is a cloudy fluid, which should be kept in the ice-chest. It rarely forms large clots, but a white flaky precipitate is usually found at the bottom of the bottle. This can be broken up by shaking the bottle before use. Filtered plasma is passed through a Seitz filter after separation. It is a clear fluid, free from the cell debris and much of the fatty contents of unfiltered plasma. The protein content varies from 4 to 5%. It must be kept at room temperature, as clotting is more likely to occur at low temperatures unless extreme care is taken in filtration. Clotting may also occur at room temperature. Since plasma is readily infected, 1% merthiolate, giving a final concentration of 1:10,000, has been added to both our filtered and unfiltered plasma. Plasma may also be prepared in a dry form (Aylward *et al.*, 1940). We have had no experience with this product and cannot therefore discuss it.

Serum has recently become available in three forms: filtered liquid, dry, and as serum citrate prepared from recalcified plasma (Clegg and Dible, 1940). We have had no experience of the latter preparation. Filtered liquid serum is passed through a Seitz filter after separation from the clots. It is a clear amber fluid with a protein content of approximately 7%. The dried serum used has been prepared by the method of Greaves and Adair (1939) at the Medical Research Council Serum Unit at Cambridge. It is reconstituted for use by the addition of distilled water and may therefore be given in varying concentration, depending upon the amount of fluid added. Neither the filtered nor dry serum used has had any preservative added.

Relative Toxicity of Plasma and Serum

In the last few months considerable quantities both of filtered and unfiltered plasma have been used in the N.W. London area. There have been no complaints of severe reactions. Actual records are available of 55·5 bottles of unfiltered plasma. Eight civilian sick and 18 air-raid casualties were treated (Table I, p. 266). Two mild rigors only were noted. Filtered plasma was given to 74 air-raid casualties and 9 civilian sick, 167 bottles in all being used. Again two mild rigors only were noted. An additional 78 bottles of filtered plasma were administered to 32 patients, together with one or more bottles of blood. Three mild rigors were seen in this group. There is therefore no great difference in the incidence of reactions occurring with filtered and unfiltered plasma. Liquid serum has only recently become available and the series of cases studied is small. Five air-raid casualties and two civilian cases have been treated, receiving between them 19 bottles containing 400 c.c. of serum each. Two rigors were noted: in one instance the serum had not been warmed before administration.

The results obtained with dried serum at both the North West and South West London

Blood Supply Depots have recently been analysed by Dr. Brown and Dr. Mollison (Brown and Mollison, 1940). Forty-seven injections were given to patients with a normal blood volume and there were 13 mild reactions. The majority occurred when the serum was given in concentrated form. Forty-four injections were given to patients with a reduced blood volume and there were six mild reactions: these all occurred when the serum was given in concentrated form. As serum will in the future be used more frequently at normal concentration, the reaction rate will probably be lower. Three hundred bottles of blood were given over the same three months' period, and 17 reactions, either rigors or fever, were noted. In one instance only, when blood over a month old had been used, was severe jaundice found. Reactions resulting, therefore, from the administration of serum and plasma appear of the same order of frequency and severity as those following the use of blood.

Relative Therapeutic Value of Plasma, Serum and Blood

(1) *In patients with reduced blood volume.*—It is extremely difficult to obtain accurate quantitative data for the assessment of the relative therapeutic value of substances that exert their effect on extremely ill patients, often seen under emergency conditions. Our own experience and conversation with transfusion officers in the N.W. London area make it clear that reconstituted serum, filtered serum and plasma are all effective in the treatment of shock. The term "shock" is used to describe a number of ill-defined conditions. I employ it here to cover those states in which there is trauma associated with circulatory collapse, lowered body temperature and pallor. In all cases in which blood-pressure records have been available, low readings have been obtained. The most reliable guide to the success of any therapeutic measure has proved to be a maintained rise of blood-pressure. In Table II (p. 266) are collected the results obtained with plasma and filtered serum alone. Unfiltered plasma was given to 18 air-raid casualties, the average number of bottles used was two. An immediate satisfactory result, as evidenced by a rise in pressure, was obtained in 15 patients. Filtered plasma was given to 74 air-raid casualties and a satisfactory result was obtained in 66, the average dose being approximately 2·1 bottles. In the case of filtered serum the number of available cases is too small to draw any clear conclusion as to average dose. Individual cases were given large doses of both serum and plasma, the maximum noted being five bottles.

Available data concerning dried serum has been analysed by Brown and Mollison (1940), who record in detail 44 transfusions to patients with a reduced blood volume. A rise of blood-pressure and evidence of hæmodilution were found in the majority of cases. The most satisfactory results were obtained when at least the equivalent of 400 c.c. of normal concentrated serum was given as an initial dose. It was originally suggested that it might be of value to give patients with a reduced blood volume fluid with a high protein content, since the injection of such a fluid might help because of its high osmotic pressure to withdraw fluid from the tissues back into the circulation. Experience has shown, however, that, though this does occur as evidenced by hæmodilution, serum with a normal concentration of protein is to be preferred in the treatment of shock. In the same period 37 air-raid casualties were treated with blood alone, receiving an average of 1·8 bottles, immediate good results being obtained in 30 patients.

It would appear from the figures given that many cases of circulatory collapse may be as satisfactorily restored by the administration of blood derivatives as by that of whole blood, but whether they alone are preferable to whole blood remains to be seen. We have been struck by the occurrence of relatively low hæmoglobin readings in patients with traumatic shock resulting from enemy action, who have had no gross and obvious source of hæmorrhage. Also patients who have been successfully treated with plasma or serum have shown on subsequent examination hæmoglobin readings in the neighbourhood of 60%. Such preliminary observations suggest that the ideal treatment for a patient suffering from air-raid shock may be one or two bottles of plasma or serum followed by one or more bottles of blood, the treatment being controlled by repeated hæmoglobin and blood-pressure readings. This procedure has been carried out successfully in 33 air-raid casualties, who received on an average two bottles of blood each and 2·3 bottles of plasma. No claim is made that the figures quoted for dosage of plasma, serum and blood respectively represent the optimum dose to be given. It is probable that many cases require larger amounts, and each case must be judged on its merits. The figures suggest, however, that there is no gross difference in the amount of plasma, serum, and blood required in patients with circulatory collapse.

The intravenous therapy of burns requires special mention. Dr. Brown has had the opportunity of seeing 12 cases of severe burns. In those cases in which it was possible

to do hæmoglobin estimations there was evidence of hæmoconcentration. This has not been hitherto our experience in traumatic shock. In burn shock, *par excellence*, there would appear therefore to be a special call for the use of either plasma or serum, for in such patients fluid of high protein content rather than hæmoglobin is needed. In the first twelve hours sufficient serum or protein should be given to restore the blood-pressure to normal. Repeated hæmoglobin estimations may be impossible owing to the extent of the burnt area: if they can be done, however, they offer a valuable additional guide to dosage. Transfusion should be begun before the patient is taken to the operating theatre to be cleaned up, and should, if the burnt area is extensive, be continued throughout this process, and, if necessary, on the return of the patient to the ward. Subsequent intravenous therapy must be determined by the condition of the patient. If localized œdema occurs at the neighbourhood of the burnt area, 200-400 c.c. of four times concentrated serum should be given to reduce this œdema. In a certain number of cases where tanning was satisfactory, this localized œdema has disappeared a few hours after concentrated serum administration. It would appear wise to continue to give concentrated serum as long as œdema persists, unless the patient becomes intolerant of fluids by mouth: in such cases normal serum is preferable. In the later toxic stages, when sepsis has become an important factor, whole fresh blood should be given, if necessary in repeated doses.

(2) *Therapeutic value of serum in patients with reduced plasma protein.*—We have had no experience of the use of plasma in the treatment of patients with reduced plasma protein. Dr. Brown has, however, studied a group of seven patients with nephrosis or nephrotic nephritis, who have received varying doses of concentrated serum. These will be published in detail elsewhere. The work of Aldrich (Aldrich *et al.*, 1938) encouraged a belief that concentrated serum might be of specific value in the treatment of nephrosis, a condition associated with low serum proteins and disturbance of fluid metabolism. The hitherto recorded results have been disappointing (Levinson *et al.*, 1940, Weech *et al.*, 1940). In only one patient in Dr. Brown's series was there definite improvement as measured by loss of œdema and diuresis. This patient received 500 c.c. in all, of four times concentrated serum, which was not the largest dose given in the series. The plasma protein rose during the course of treatment from 4 to 5·4 grm.

Such evidence as is available suggests therefore that there is no marked difference in toxicity, dosage, or efficiency between serum and plasma in the treatment of conditions associated with a low blood volume. Less data are available to enable an assessment of their value in conditions associated with a low plasma protein. Concentrated serum would appear to have a special place in the later treatment of burns, but to be of little or no use in patients with nephrosis.

Apart from clinical considerations, serum is certainly an easier fluid to handle in large quantities than plasma. It is not readily infected and does not clot. Plasma, on the other hand, appears an ideal culture medium and has peculiar and unaccountable tendency to form clots. This formation of clots spoils the appearance of the preparation and makes it less easy to use, as the clot tends to block the filter. Further, the process of clotting removes the fibrinogen, so eliminating the essential difference between plasma and serum. If fibrinogen proves to be of any importance in patients with shock, plasma is clearly to be preferred to serum. If high protein content is of importance, serum, since its protein content is 2-3% higher, is clearly preferable to plasma. Dried serum, which requires no special temperature for storage and can be kept in a small space, has obvious practical advantages over a more bulky fluid preparation requiring some degree of temperature control.

Concentrated Red Cells

There is a varied group of patients with anæmia in whom it may be important to raise the hæmoglobin level rapidly without necessarily increasing the blood volume.

(i) Elderly subjects in whom immediate operation is indicated; (ii) anæmia associated with prolonged sepsis; (iii) aplastic anæmia.

Patients in the first two groups have done well when given a concentrated suspension of red cells. Our practice has been to use Group O blood which has stood in the ice-chest for not less than five days and not longer than fourteen days. The supernatant plasma is withdrawn and used as such. The white cell debris lying on the surface of the red cells is then removed by the same closed section system used in taking off the plasma, and one bottle of red cells is then added to another. If necessary, in order to fill the bottle to the 540 c.c. mark, a little 3% citrate solution has been added.

This preparation has become increasingly popular. As originally noted by MacQuaide and Mollison (1940), the incidence of reactions has been extremely low, and the rise

in hæmoglobin obtained has been satisfactory. Preliminary observations suggest that the length of life of such cells, after transfusion, varies with the type of case. They have disappeared from the circulation extremely rapidly in two patients with obscure anæmia and splenomegaly, while in anæmia dependent upon blood loss or sepsis the hæmoglobin level has remained raised for considerable periods. One bottle raises the hæmoglobin by approximately 16%.

Conclusions

In conclusion, we feel that all blood derivations have proved their use, but that more detailed clinical and chemical studies are needed in order to assess their relative values. It is doubtful indeed whether such controlled accurate observations can be made under *blitz* conditions; ordinary surgical shock is clearly not comparable, but possibly severe industrial accidents might provide suitable material for careful investigation. Our observations up to date have been qualitative rather than quantitative.

Table I.

	No. of bottles	No. of reactions
Unfiltered plasma	55½	2
Filtered plasma	167	2
Filtered serum	19	2
Dry serum		
Normal blood volume :—		
×4 concentrated	31	12
×2 concentrated	10	0
N concentration	6	1
Total	47	13
Reduced blood volume :—		
×4 concentrated	31	6
×2 concentrated	7	0
N concentration	6	0
Total	44	6
Blood	300	17

Table II.

	No. of cases	Average No. of bottles used	Result Immediate good	Death
Plasma unfiltered				
Air raid	18	2	15	4
Civilian	8	2·5	8	2
Plasma filtered				
Air raid	74	2·1	66	10
Civilian	9	1·4	8	2
Filtered serum				
Air raid	5	2	4	2
Civilian	2	4	2	2
Blood				
Air raid	37	1·8	30	7

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Section of Odontology

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[*January* 27, 1941]

Surgical and Dental Treatment of Fractures of the Upper and Lower Jaws in War Time

A Review of 119 Cases

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THIS communication deals with the surgical and dental management of 119 cases of fractures of the upper and lower jaws which have been treated in an E.M.S. Maxillo-Facial Unit between September 3, 1939, and December 31, 1940. The group does not include other fractures of the facial bones without particular dental interest. As will be seen, the causes, distribution and varieties of these fractures and their associated complications differ very greatly from those seen in civilian practice, and they have consequently presented problems new to many of us. It is a pleasure to record in this connexion the value of the ripe experience and balanced judgment of Sir Harold Gillies and Mr. Kelsey Fry, who have throughout guided the surgical and dental policy of the Unit and established sound rules of procedure from which we have deviated little. At the same time investigation is actively proceeding in the Unit by D. G. Walker into the question of condylar fractures, and by McLeod, Shepherd and Clarkson into various problems of immobilization.

The results obtained are therefore not in any sense due to one person but reflect the combined efforts of a team working in close collaboration, an ideal not always possible in ordinary times, but one which is certainly most useful where considerable numbers of cases can be concentrated in one unit. The majority of these patients were treated at East Grinstead, but some who had sustained associated injuries were dealt with in other hospitals by means of a mobile team. A completely equipped Dental Ambulance presented to the Maxillo-Facial Service by the American Dental Association, and staffed by a plastic surgeon, dental surgeon, anæsthetist and nurse has made many trips to other hospitals and has clearly demonstrated its use and the great value of early skilled treatment in difficult cases.

Material

Total number of patients with fractured jaws	.. ..	119
Total number of patients with fractured jaws, but without other injuries	.. ..	68
Total number of patients with fractured jaws, with other injuries	.. ..	51
Fractures of the mandible	.. ..	82
Fractures of the maxilla	.. ..	37
Fractures of the mandible and maxilla	.. ..	7

As might be expected, a considerable proportion (43%) of the patients had associated injuries which varied from extensive soft tissue lacerations to fractures of long bones or skull injuries, depending on the cause of the trauma. Immediately, therefore, the importance of the surgical aspect of the dental treatment becomes apparent. It has been the effort of the Unit to work out the most suitable plan of treatment so that none of the lesions should be neglected at the expense of others, and especially that the patient should not be overtreated. As an example one might cite the advantages of interdental eyelet wiring as an efficient first aid or temporary measure in a patient with a fractured femur in whom as little disturbance as possible is advisable in the early stages. Later more elaborate forms of fixation might be used.

Sex and age (Males, 101 ; Females, 18).—These varied in age from 6 to 72 and the distribution of age-groups is shown in fig. 1. As would be expected, the highest incidence is among fit young men on active service between 18-35, but there is a secondary rise among older people due to bombing of the civilian population. Most of these occurred in patients sitting quietly at home, and again, in many, associated injuries were common.

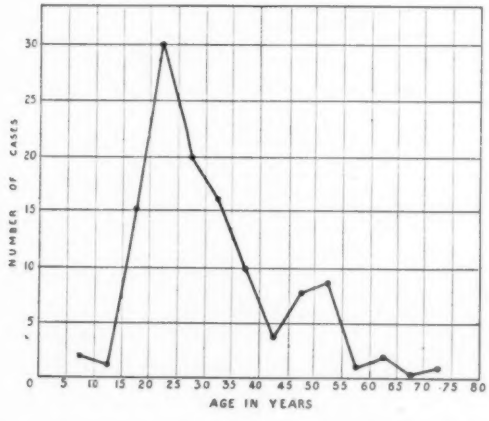


FIG. 1.—Distribution of age-groups in 119 cases of fractures of the upper and lower jaws treated between September 3, 1939, and December 31, 1940.

Causes.—

Bomb and shell fragments. Mine explosions, &c.	Mostly penetrating or perforating wounds and fractures	45	
Gunshot wounds			9
Collapse of buildings	Mostly severe comminuted fractures with gross displacement	16	
Motor-car, motor-cycle collisions		23	
Plane crashes		8	
Blows, kicks, &c.	Mostly localized fractures without external wounds	9	
Falls		9	
		119	

As opposed to the relatively small group of cases (18) in which blows, kicks and falls were responsible for the injury—which was usually of a localized, uncomplicated type—by far the majority were the result of extreme violence. Thus bomb and mine explosions and penetrating missiles accounted for 54 (45%), producing in many severe facial injuries with localized but severe bony damage, while the collapse of buildings when the patient was struck by a mass of masonry, or hurled head first on to it, produced 16 (13%). In a high speed war it might be expected that head-on crashes in aeroplanes, motor cars

and motor cycles would prove a prolific source of facial fractures, and indeed they come second only to the effect of high explosive, 31 (36%). In this group there was maximum of bony damage and displacement often involving both upper and lower jaws, with a minimum of soft tissue injury.

Distribution of the Fractures of the Mandible.

Fractures of the mandible	82	
Partial fractures	4	
Complete fractures	78	
(*a*) Single	21	
(*b*) Double	22	
(*c*) Multiple and comminuted	35	
Mandibular fractures unassociated with external injury	48	
Mandibular fractures associated with external injury (penetrating or perforating injuries)	34	
Mandibular fractures with loss of bone, requiring bone graft	10	

Situation of the Fractures.

Body	37
Symphysis	34
Condyles	34
Angle	18
Ascending ramus	9
Coronoid	4

Here again the excessive violence of the trauma tended to produce a much more severe bony injury than one encounters in civil life, though it might be said that the specialized nature of a maxillo-facial unit would naturally attract the more severe type of case. 70% of the mandibular fractures were either double, multiple or comminuted, and 12% sustained such a bony loss that a bone graft has been, or will be, necessary. In considering the situation of the fractures it is of interest to note the very high incidence of unilateral and bilateral condylar fractures, a great many of which resulted from heavy, unexpected blows on the point of the jaw. Apart from this, the distribution and combination of the fracture lines followed that generally known to be common.

Fractures of the maxilla	37	
Partial alveolar		4
Unilateral		20
Bilateral		8
" Middle third facial " crush fractures		5
Fractures involving both mandible and maxilla	7	

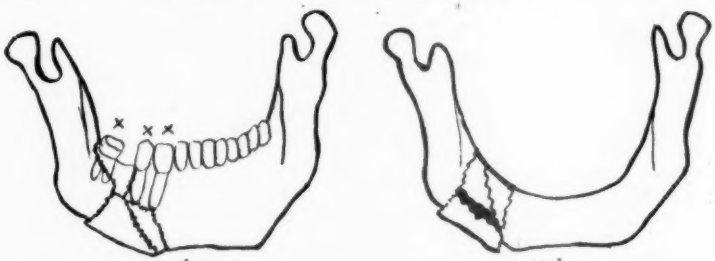
These were almost always due to head-on crashes and other forms of extreme violence. As will be pointed out later, they form a difficult group, for they are commonly associated with severe neurological and other injuries, so that treatment must often be delayed until the general condition of the patient improves. As displacement and impaction in these fractures is always the result of the trauma and is not due to muscular pull, satisfactory operative reduction is not always possible. This is particularly true of bilateral maxillary and the so-called "middle third facial" fracture, in which the entire nasal maxillary compound is crushed or thrust bodily backwards into the face.

Examination.—After careful clinical examination of the entire bony structure of the face, X-rays are taken to confirm the findings. These include antero-posterior and lateral view of the head, rotated views of the lower jaw to include the temporo-mandibular joints, supplemented if necessary by dental films. At the same time 30° and 90° occipitomental views are used to estimate nasal, malar and maxillary fractures and displacements.

Immediate treatment of acute facial injuries complicating fractured jaws.—The initial treatment of the soft tissue injury differs considerably from that adopted in similar injuries in other parts of the body where radical excision of the damaged tissues and removal of all foreign bodies is essential at the earliest possible moment to avoid sepsis

1 and 2.—Mandibular fracture. Point of entry of bullet wound visible on right side. Soft tissue injury without loss. Immediate suture with dependent drainage.

3 and 4.—Mandibular fracture with lacerated infected wound. Moderate soft tissue loss. Packed open with saline gauze. No sutures.



1 and 2. 3 and 4.

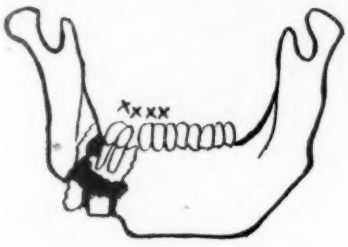
Drawings of the fractures underlying the facial wounds shown above.

1 and 2.—Compound comminuted fracture right molar region. Extraction of teeth in line of fracture (x). Eyelet wiring for fixation, later cap splints. Uneventful recovery. 3 and 4.—Compound comminuted fracture right molar region. Edentulous jaw. No loss of bone. Gunning splint. Uneventful recovery.

FIG. 2.

and gas gangrene. The good blood supply of the facial tissues and jaws and their well-known resistance to infection allow considerably greater latitude, and it cannot be denied that early suture of the soft tissues and immobilization of the jaw fragments will give the best results.

In war time the high incidence of associated soft tissue injuries makes it essential that some rules should be laid down with regard to their immediate surgical treatment, consistent with the adequate handling of the underlying fracture. In the Unit the two problems are considered at the same time, the plastic surgeon dealing with the facial injury, the dental surgeon making impressions, localizing fragments and preparing and adjusting splints.



5 and 6.

5 and 6.—Compound comminuted fracture right molar region with external wound. Extensive loss of bone and soft tissue. Teeth and bone fragments removed (non-viable). Mucous membrane sutured to skin edges round bone ends. Major fragment splinted to maxilla. Rapid healing with large defect. Will require soft tissue plastic repair and bone graft to lower jaw.

FIG. 2a.

Several factors are important : (*a*) *Time factor* in relation to infection. Within the first twelve hours facial injuries may be sutured with impunity provided great care is taken to cleanse the wounds thoroughly with soap and water and saline, and to remove thoroughly (with a sharp steel curette if necessary), all foreign bodies, dirt, &c., which

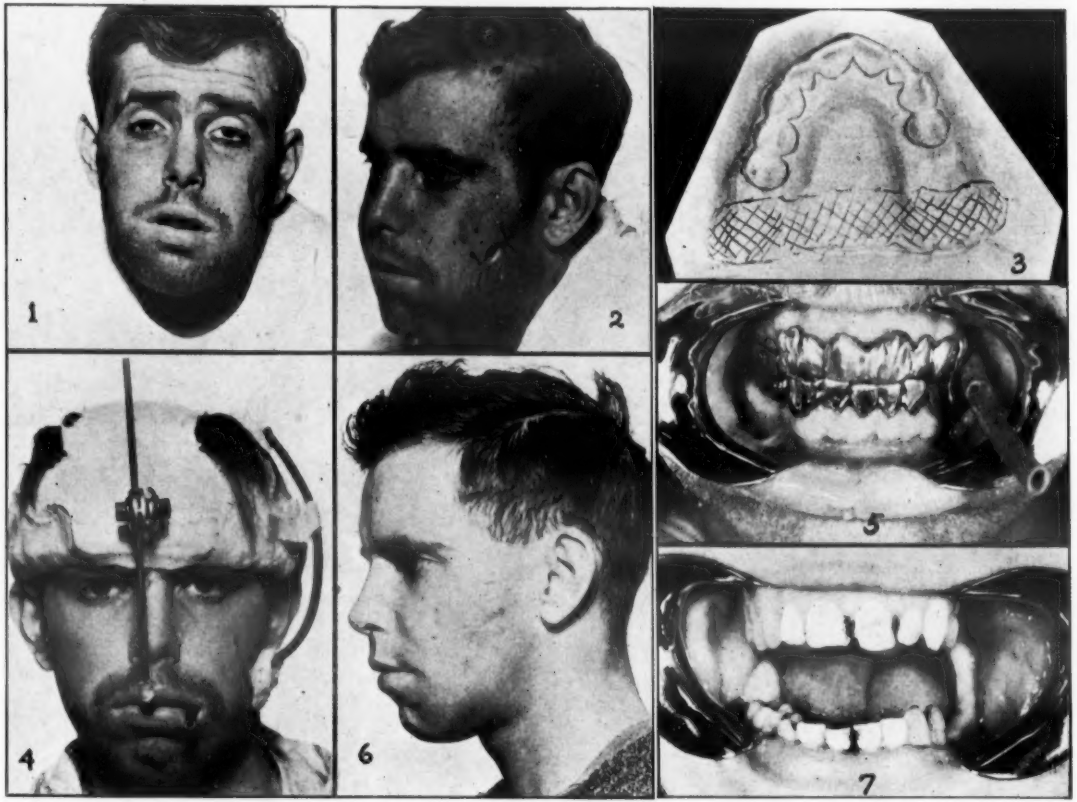


FIG. 3.—Compound fractures upper and lower jaws. Gunshot wound. Entrance right cheek, exit left cheek. Loss of both maxillary tuberosities, laceration of soft palate, comminuted fracture left ascending ramus. Fractured maxillæ with both antra open. Treatment: Locking cap splints with steadying headgear for maxillæ. Intermittent hypertonic saline irrigation of wounds. 1 and 2. Small entrance and exit wounds. 3. Path of bullet. 4. Fixation and irrigation. 5. Splints in position. 6 and 7. Result after excision of scars.

may have been ground in. Non-viable pieces of bone only are removed, and extreme conservatism is practised in regard to any pieces which have the slightest chance of survival. Excision of wounds is unnecessary except for the removal of non-viable tissue or to make accurate suture of severely damaged skin edges possible. Suture can be performed up to twenty-four hours, but after that it is probably inadvisable for the risks of sepsis rise steeply. After this time the wounds should be packed open with saline gauze which is changed frequently (fig. 2).

(*b*) *Wound tension.*—The mechanical possibility of wound suture largely depends on whether or not tissue has been lost, and the amount of this should be carefully estimated. If it is such that undesirable tension is produced and especially if the displacement of the fragments is perpetuated or increased, it should not be attempted. It is remarkable how well a facial wound, packed widely open with saline gauze, will heal in the absence of all tension, and how rapidly a breakdown will occur under the reverse conditions. Comparatively little scar results from the former procedure, but the subsequent removal of the marks of badly placed sutures which have cut in is far from easy. In full thickness losses of the cheeks, including bone, it is better to suture the mucous membrane of the buccal surface to the skin edges round the bone ends in such a way that the bone is protected and the raw surface exposed to infection is reduced to a minimum. Conservative treatment of this type is essential if deformities difficult to cure later are to be avoided (fig. 2a).

(*c*) *Drainage.*—All compound injuries of the jaws associated with external wounds should be adequately drained at whatever time they are seen. Delay in healing is often due to inadequate initial drainage. The drain should be in a dependent position and preferably a rubber tube of sufficiently wide bore to allow frequent irrigation and to obviate blocking. A gauze wick is unsatisfactory, for it simply dams up the drainage hole. Shepherd has devised a most effective method of saline drip irrigation through a catheter into those gunshot wounds of the jaws with small points of entry and exit, but severe damage within the mouth, in which dependent drainage is not easy. The saline is run in from time to time from a thermos flask type of irrigator above the patient's head, controlled by the patient himself (fig. 3).

Treatment of the Fractures

(1) *Mandible*

With the completion of the soft tissue suture by the plastic surgeon in those fractures requiring it, the patient is then handed over to the dental surgeon. The ideals to be aimed at are the permanent immobilization of the fragments and the clearing up of sepsis in the fracture lines. It is unnecessary to describe here first-aid methods of treatment which a special centre of this nature would rarely employ, though it might be said that cases have many times been admitted so efficiently immobilized by eyelet or other wiring methods that it has been unnecessary to make any alterations. A survey of the types of treatment used in the Unit would show that cast metal cap splints have proved the most satisfactory form of immobilization and are used in the vast majority of cases (71%).

Methods of immobilization.—(1) Interdental eyelet wiring. This has occasionally been used with satisfaction, particularly if the fracture is of moderate severity, and there is a good complement of teeth. It fails, however, in severe injuries and particularly where the fragments contain few sound teeth (fig. 4).

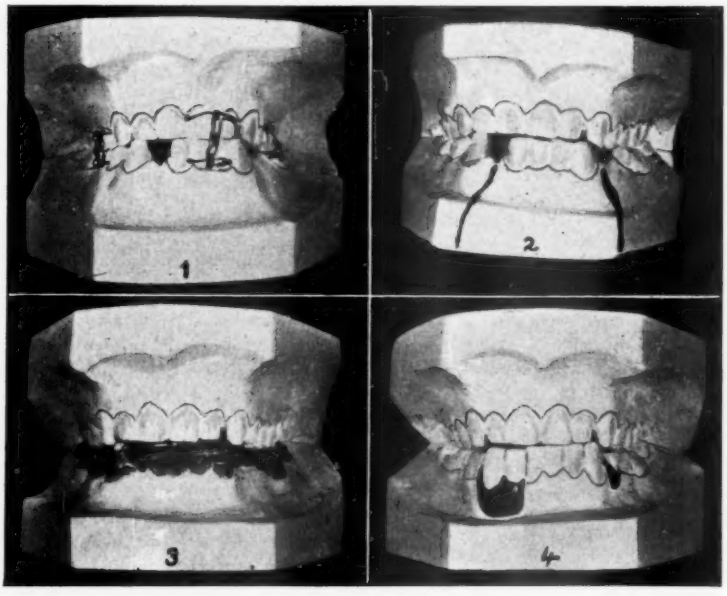
(2) Intermaxillary arch wiring. Various modifications of this, such as Winter's studded arch wires and plain stout wires attached to rings cemented to the teeth have also been used and are still on trial (fig. 5).

(3) Cast metal cap splints. These remain the method of choice for the following reasons (figs. 6, 7, 8): (*a*) They give positive fixation and stable immobilization; (*b*) they can be modified in so many ways that they are applicable to practically all except edentulous cases; (*c*) there are no wires to break or readjust, and the patient can be safely sent home during the convalescent period; (*d*) in certain fractures of the lower or upper jaws a single rigid splint is sufficient and mastication can be carried on throughout treatment; (*e*) with the incorporation of locking devices, flanges, hooks, &c., many problems difficult of solution with wiring methods can be successfully overcome; (*f*) the

bullet. 4. Fixation and irrigation. 5. Splints in position. 6 and 7. Result after excision of scars.

occlusal surfaces of the splint can be cut away to bring the upper and lower teeth in actual contact if desired. There is some evidence that this is not altogether desirable; (g) cap splints well applied do not harm the teeth or gums.

(4) Gunning type splints. These are used in edentulous jaws. Circumferential wiring has not so far been used.



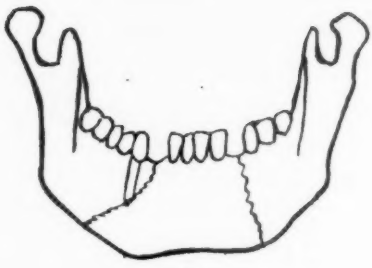


FIG. 4.—1. Fractured mandible. Bilateral canine fracture. Immediate treatment good eyelet wiring but right canine in line with fracture. Suppuration. 2 and 3. Cap splints applied and lower right canine cut beneath splint and extracted. 4. Denture. 5. Tooth in fracture line; site of fractures.

Control of sepsis.—Teeth in the fracture lines are removed, especially those with broken and septic roots. There are some notable exceptions. Where only one tooth remains on a fragment it should be retained as long as it is of value in immobilizing the fragment.

Later it can be removed. Unerupted third molars lying in fracture lines are best left until sufficient consolidation has occurred to make removal safe. If it is thought that the removal of a tooth in the fracture line will be attended by further trauma, it is possible to devise a cap splint which can exclude the offending tooth. After the application of the splint it can be cut out without further disturbance.

Mention has already been made in regard to conservatism in the removal of bone fragments. But in those cases with extensive loss of bone, in which grafting is inevitable, one might be more radical in the removal of bone fragments which serve no useful purpose in the subsequent grafting operation.

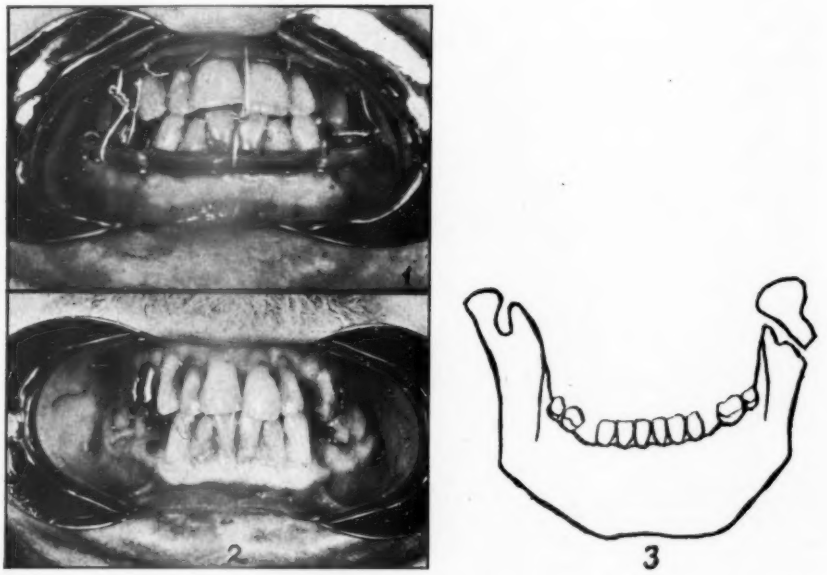


FIG. 5.—Left condylar fracture. Treatment by rubber-covered arch wires to fix upper and lower jaws for short period. Rubber prevents chafing of lips and cheeks. Early movement. 1. Arch wires in position. 2. Result. 3. Site of fracture.

Careful irrigation of the fracture cavity and a rigid toilet of the mouth is essential if sepsis is to be prevented. Food must not be allowed to collect between the bone ends. Submandibular drainage is rarely necessary in simple fractures, but is always carried out where penetrating wounds have occurred, usually with comminution. The following figures are instructive :—

Mandibular fractures with perforating wounds—all drained	.. .. ..	34
Mandibular fractures without perforating wounds.	No abscess, no drainage ..	42
Mandibular fractures without perforating wounds.	Abscess requiring drainage	6

Removal of sequestra.—During the period of immobilization, and particularly in comminuted fractures with perforating wounds, sequestra are extruded. If a purulent discharge persists beyond six to eight weeks, the fracture cavity should be gently curetted, and any dead fragments of bone removed. This may be repeated if sequestration is not complete. In simple fractures the splints are removed after four to six weeks and the mandible tested for union. They are reapplied for a further four weeks if this is not sufficient. Consolidation may take a considerable time (three-four months) in perforating wounds with extensive comminution, but eventually occurs.

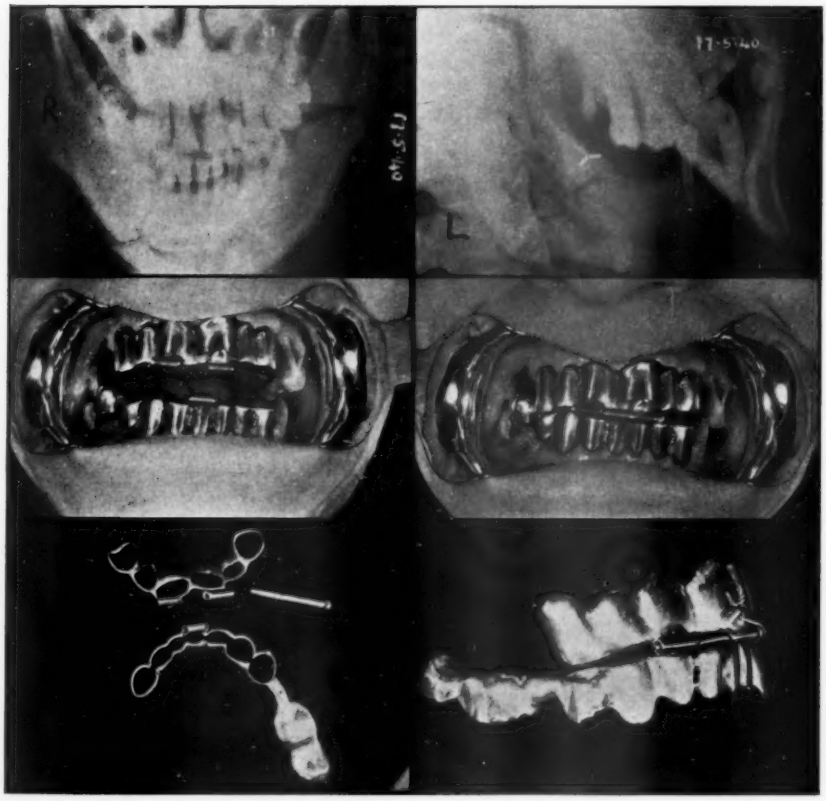


FIG. 6.—Fractured mandible. Left angle and right second premolar regions. Treatment: Open cap splints with pin lock.

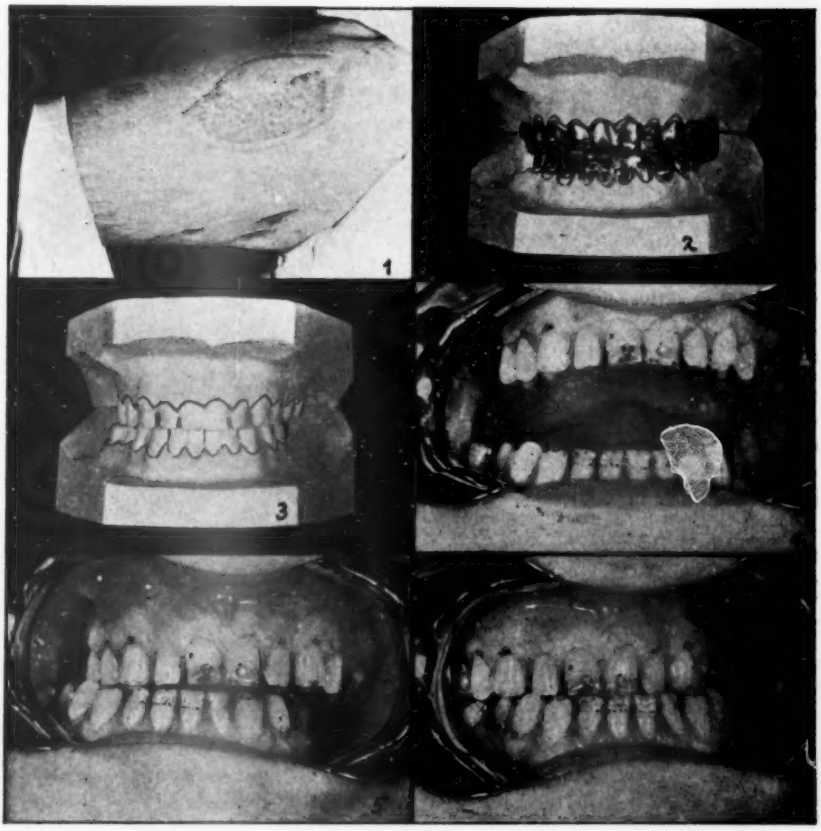


FIG. 7.—Mandibular fracture right ramus with extensive associated injuries necessitating mobile team. Impressions taken and upper and lower cap splints made with left flange to prevent lingual movement of major fragment. 1. Injury to leg (grafted). 2. Cap splints with flange locked. 3, 4, 5 and 6. Result with range of movement demonstrated.

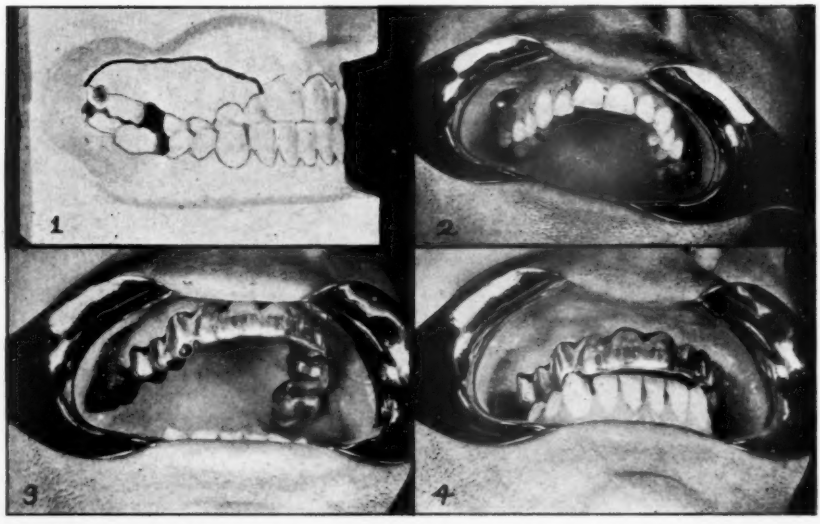


FIG. 8.—1. Partial fracture right maxilla. One week old. 2. Attempted reduction with elastic traction without result. Manual replacement under gas and oxygen. 3 and 4. Result with full upper cap splint.

(2) *Maxilla*

Since the degree and direction of displacement of maxillary fractures are directly related to the severity and direction of the blow producing them, and are not related to muscle action, early disimpaction and immobilization of the fragments is essential. The responsibility for forcible manual reduction of these fractures has rested with the plastic surgeon, who should be able to hand the case over to his dental colleague with the fragments repositioned and ready for splinting in normal dental occlusion. Partial alveolar fractures and complete and unilateral maxillary fractures can, as a rule, be disimpacted with the fingers and returned to position, after which they are immobilized by means of a complete cap splint uniting the broken to the sound side.

Bilateral maxillary fractures constitute a much more serious problem. Here a variety of conditions may be encountered :—

(*a*) The hard tooth-bearing alveolar segment, including the entire palate, may be sheered away from the lighter antral maxillary superstructure, and either impacted into it to produce an open bite, or forced backwards so that the lower teeth overlap the uppers. Median separation of the halves of the palate sometimes occurs. Occasionally the antral superstructure is so crushed that the tooth-bearing segment "floats", and is attached only by soft tissue to the face.

(*b*) The entire middle third of the face, including the nasal bones and maxillæ, is thrust bodily backwards between the malar bones into the ethmoid region to produce the well-known "dish face" deformity.

It is of extreme importance that fractures of these types should be disimpacted at once, for if consolidation occurs, replacement is extremely difficult. It can be effected by gripping the maxillary alveolus with special forceps, and by rocking and rotatory movements disimpacting it sufficiently to bring it forward until the teeth occlude correctly. In the "middle third" crush fracture the disimpaction of the nasal bones must also be carried out.

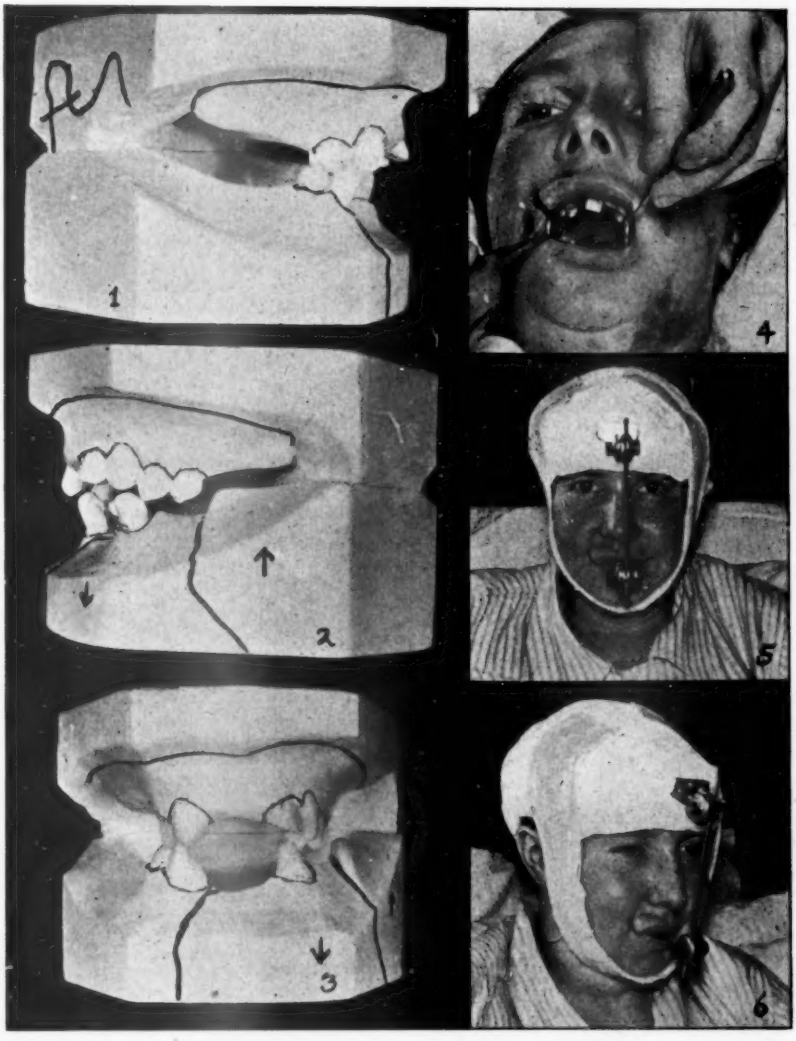


FIG. 9.—1, 2 and 3. Multiple fractures upper and lower jaws with " floating maxilla ". Right condyle, right canine region, left premolar region. 4. Broken incisors extracted. 5 and 6. Rigid external headcap fixation of maxilla with lower cap splints attached to upper splint. Elastoplast support.

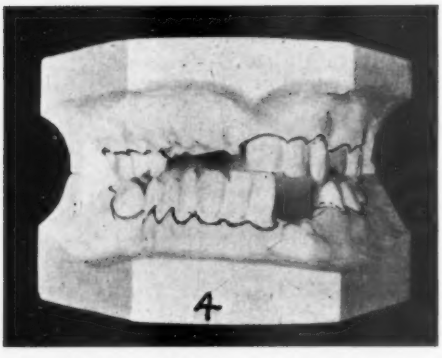


FIG. 10.—1, 2, 3 and 4. "Middle third" crush fracture of maxilla with posterior displacement of entire bony mass, including nasal bones.

Immobilization in all fractures of this type depends on finding a point of resistance upon which to splint within the bony facial structure or if none is available, creating one by external means. Thus moderate displacements of the maxillary arch can, after replacement, be splinted to the lower teeth with full upper and lower cap splints (fig. 9). Elastic traction is of use in making minor adjustments in position. If the maxilla is very loose and the antral superstructure is intact, upward traction with a Kingsley type splint and plaster head cap is advisable, but if even this point of resistance is lost where the antra are crushed, the rigid type of external fixation and head gear is essential (figs. 10 and 10a).

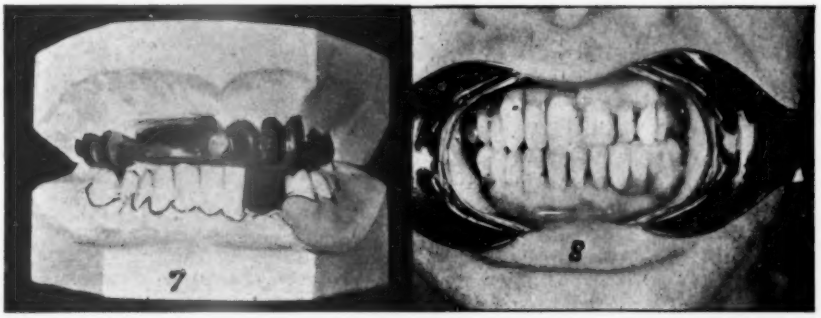


FIG. 10a.—5 and 6. Surgical replacement followed by fixation with headcap and spring traction. Spring splints fitted. Nasal splint in position. 7. Upper cap splint. 8. Result.

The accurate repositioning of a badly impacted maxillary fracture is not always an easy matter, particularly when the nasal and malar bones are involved. Here constant external traction by wires or elastic bands to bars projecting from a head cap has given good results.

Surgical complications and sequelæ of fractured jaws.—It is unnecessary to dwell on the fortunately rare cases of non-union and malunion. The former usually entails a thorough

revision of the local condition, and the elimination of such factors as sepsis, sequestra, teeth in the fracture line and inadequate immobilization. The latter may mean surgical division of the fracture and resplinting in correct position.

(*a*) In the lower jaw this is a comparatively easy matter and can be accomplished by passing a Gigli-saw round the site of fracture and dividing the jaw transversely.

FIG. 11.—Gunshot wound, right temporal region with loss of right condyle. Plastic repair by swinging flaps and coincident control of lower jaw by cap splints and elastic to prevent slewing to the right until consolidation effected.

(*b*) The secondary or delayed replacement of the fractured and retroposed maxilla can be extremely difficult. The best results are obtained where the tooth-bearing segment alone is transversely fractured. An operative approach to the fracture lines is made through the upper buccal sulcus. These are divided with chisel and hammer, and an attempt made to cut through the fibrous adhesions uniting the upper and lower segments.

If the two segments are sufficiently loosened to allow the lower one to come forward, external elastic traction can then be applied to retain the teeth in the over-bite position. When occlusion is satisfactory the teeth are locked together with full upper and lower cap splints. Where the entire middle third of the face is retroposed, including the lower maxillary tooth-bearing segment, it may be possible by direct external traction, using a weight and pulley, to advance the jaw.

Soft tissue deformities.—These may entail the simple removal of scars or the most complicated procedures for the repair of extensive soft tissue losses. Operations are, as a rule, undertaken when the fracture is soundly healed and the patient has had a period of convalescence to enable resolution to occur. For the most part these operations have little bearing on the dental problems under review. Operation for microstoma resulting from burns have, however, occasionally been necessary in order to enable the dentist to work at all (figs. 11 and 12).

FIG. 12.—1 and 2. Severe facial burn with microstoma. Impossible to fit dentures. 3 and 4. Mouth opened by plastic operation enabling dentures to be fitted.

Repair of the obliterated buccal sulcus.—A considerable number of severe compound fractures of the jaws, particularly due to perforating missiles, result in obliteration of the buccal sulcus to such an extent that the satisfactory fitting of dentures is impossible. Almost all cases which have been bone grafted fall into this category. It becomes necessary then to deepen the upper or lower buccal sulci by dividing the adhesions between the lips and alveolar surfaces and to line the resultant cavity with a skin graft. Splints adapted to suit special circumstances are made to carry a tray which supports the stent mould, which in turn presses the graft firmly into the cavity.

Well-fitting dentures can be applied as soon as the graft is well established. Under no circumstances during the contraction phase should the cavity be allowed to remain without the retention block in situ for more than a few minutes, or rapid and irretrievable contraction will take place. The contractile phase lasts usually from four to six months (figs. 13 and 14).

Trismus.—A few cases of mandibular fractures develop trismus, particularly those high condylar lesions involving one or both temporo-mandibular joints. The circumstances which produce ankylosis of the joints are not quite clear, for it has occurred even when

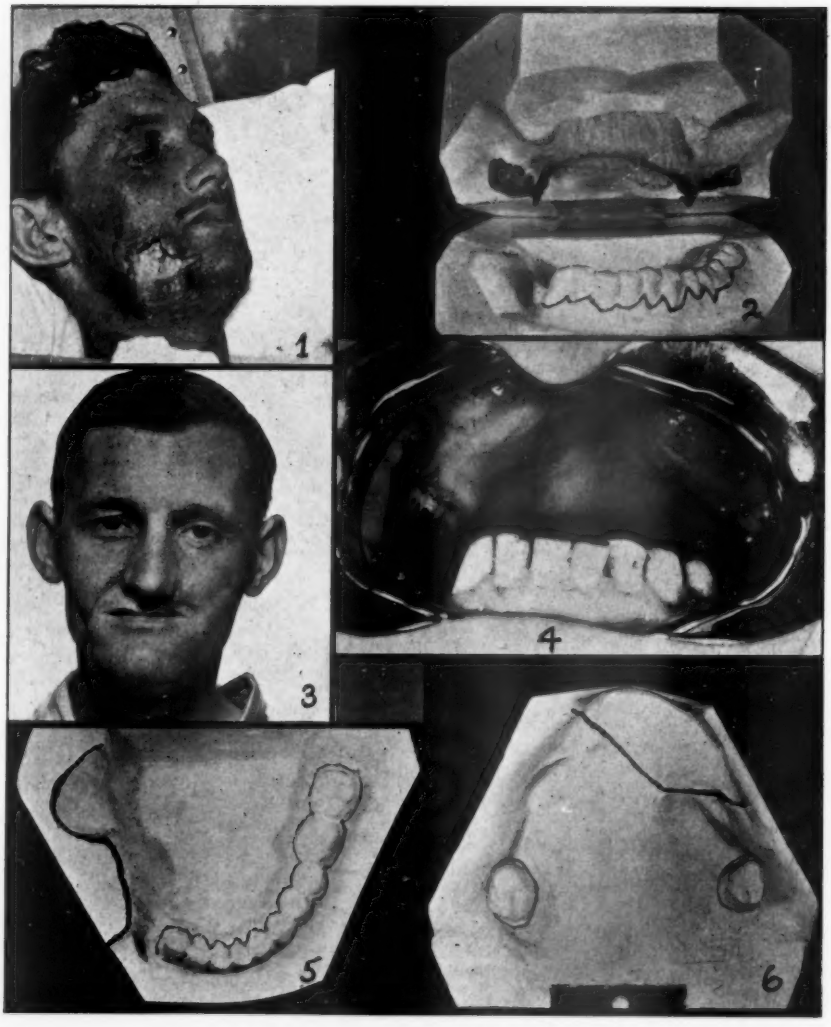


FIG. 13.—1 and 2. Compound fractures upper and lower jaws with bony loss of alveolæ. Gunshot wound. 3, 4, 5 and 6. Healed condition showing bony loss and destruction of upper and lower buccal sulci making fitting of dentures impossible.

movement has been begun early. Coincident coronoid involvement is said to favour it. In the early stages an exerciser of the type shown is used to keep constant pressure against temporal muscle pull, and maintain a full range of movement. If this fails it becomes necessary to resect one or both condyles, including half an inch of the mandibular neck to form a false joint. The jaws are fixed together for one week, after which the exerciser is used to regain movement. The amount of elastic traction used on the exerciser

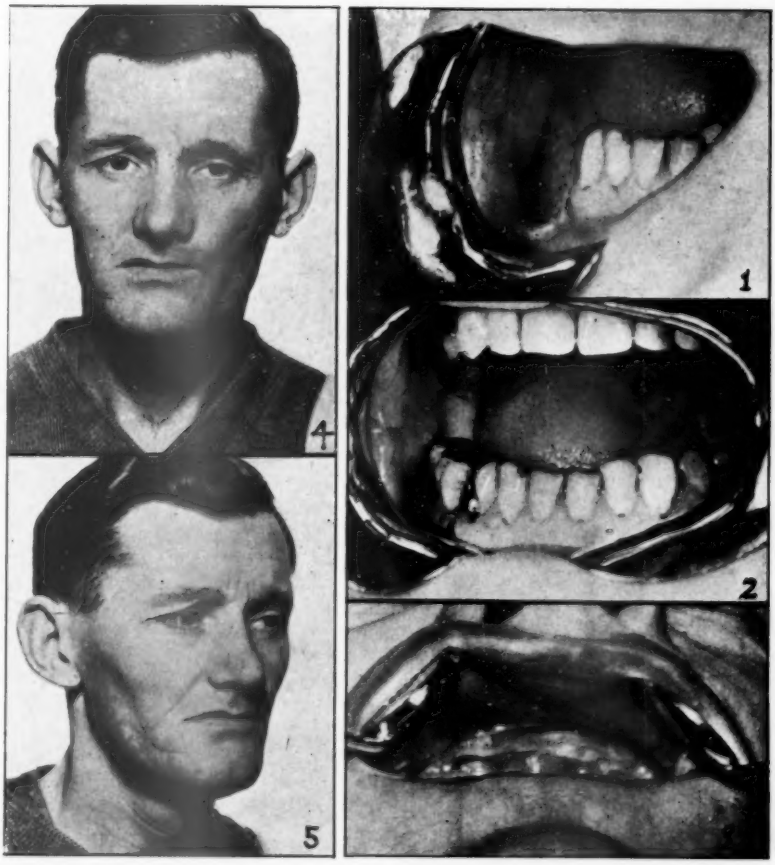


FIG. 14.—1, 2 and 3. Epithelial inlays into upper and lower buccal sulci making fitting of dentures possible. 4 and 5. Result after excision of scars and fitting dentures.

should not be too great or applied too early, for it is easy to thrust the shortened mandibular neck up into the glenoid cavity with resultant open bite due to gagging of the third molar teeth (fig. 15).

Apart from the question of trismus, condylectomy has been performed once for severe persistent pain, of a neuralgic type, caused by a fractured and dislocated right condyle,

in which the head lay medial to the neck in the pterygoid fossa, and united to its inner aspect at right angles to the axis of the ascending ramus.

Bone grafting of the mandible.—Extensive losses of the mandible have been seen from gunshot wounds and high explosive fragments. 12% of the cases so far treated have been, or will be, bone grafted. In general a gap of 1 cm. uncrossed by periosteum and without

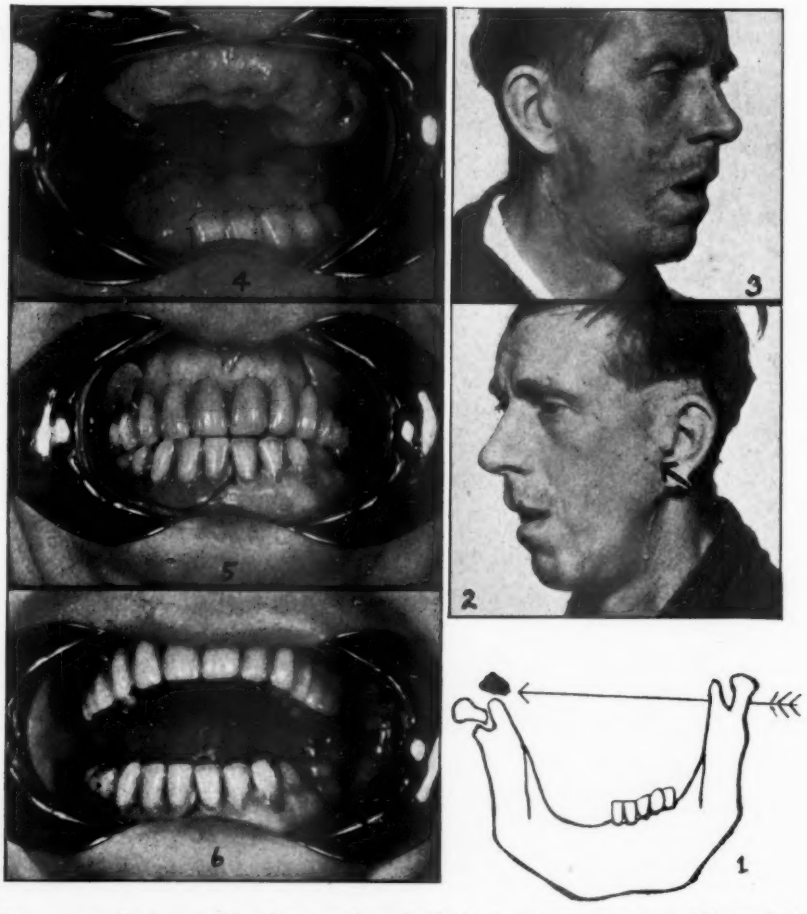


FIG. 15.—1. Right condylar fracture from bomb fragment, passing from left to right. 2, 3 and 4. Seen one month later with trismus and open bite. Bomb fragment had damaged left temporomandibular joint in addition to fracturing right condyle. Treatment: Bilateral condylectomy and movement. 5 and 6. Dentures fitted and movement after operation.

intervening viable bone fragments will result in non-union. In those cases in which there is no doubt that a bone graft will be required there is little to be gained by attempting to save small pieces of bone between the major and minor fragments. Time is saved and the subsequent operation made easier, if the problem is reduced to the simple one of

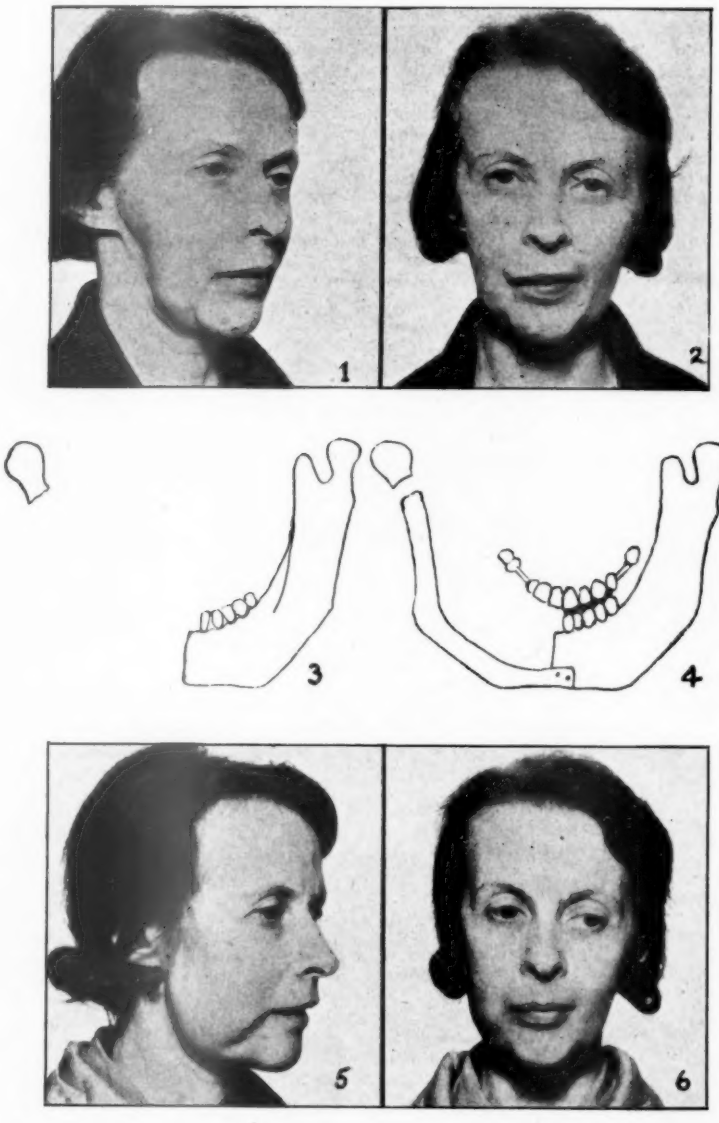


FIG. 16.—1, 2 and 3. Loss of half the mandible. 4. Left half retained in position by cap splints locked to the upper jaw. Bone graft from right iliac crest replacing the bony loss. 5 and 6. Note the excellent contour.

bridging the gap between two perfectly clean bone ends. There is practically no limit to the size of gap which can be satisfactorily grafted (fig. 16). Thus the practice of the Unit is to strive for occlusion with union wherever possible, but if good occlusion is not compatible with union because of bony loss, non-union with subsequent bone grafting is willingly accepted. A bone graft is not inserted until four to six months have elapsed from the last signs of sepsis. During this time the fragments are splinted to each other by the rigid bar type of cap splint so that movement is possible without lingual collapse of the fragments, or they are splinted to the upper teeth in the more extensive unilateral losses.

Formerly bone grafts were of different types, and were derived from different sources (e.g. osteoperiosteal, sliding mandibular, tibial, &c.), but the eminently satisfactory iliac crest graft has entirely supplanted other methods. Bone from this source is tough, can be bent and shaped, is highly osteogenetic, and is easily obtained in amounts sufficient for the smallest or the largest bone graft without disability to the patient. The grafts, after shaping, are wired accurately between the exposed fragments, using stainless steel ligatures. Union should be firm in four weeks and movement can then be allowed.

Mortality.—Only one patient has died under treatment during this period: a man of 72, with a large perforating wound and fracture of the maxilla, in whom a sudden uncontrollable hæmorrhage from the internal maxillary artery proved fatal.

I wish to express my indebtedness to my colleagues, Mr. Alan McLeod, Mr. D. G. Walker, Mr. Shepherd, and Mr. Alan Clarkson for their great help and co-operation in this paper.

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President—C. P. SYMONDS, M.D.

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The Neurological Approach to Mental Disorder

PRESIDENT'S ADDRESS

By C. P. SYMONDS, M.D.

THAT there is an approach to the study of mental function by way of neurology would, I suppose, be denied by no one prepared to admit that brain is the organ of mind. By implication the brain contains what Hughlings Jackson called the anatomical substrata of mental processes, and all mental activity happens through the brain. So common experience teaches without exception. This does not mean that what may appear as mental disorder must be due to disease of the brain. We know that the kidney is the organ of urinary secretion. Without the kidneys there is no urine, just as without the brain there is no mind, but abnormalities in the quantity or constituents of the urine do not always mean that the kidney is diseased. They may indeed, when fully understood, show the kidney to be exercising its normal function, the disease being elsewhere, as for example in diabetes. We may compare abnormality in the quality and quantity of mental function as result of thyroid defect. Here the analogy ends. There can, of course, be no comparison between our knowledge of the relationships of kidneys to urine, and brain to mind. Yet it is legitimate hypothesis to suppose that between the anatomical substrata of consciousness, and consciousness itself, there is functional correlation. If so, neurophysiology would deserve reproach if it did not press towards the understanding of mental activity.

Neurophysiology is a young science. It may be said to have grown from infancy to full stature within the lifetimes of two men in our own country—Hughlings Jackson and Sherrington. It is a remarkable fact that the former was a clinician with no first-hand experience of the experimental method, who nevertheless deduced from observation in cases of nervous disease rules which have been of incalculable value for physiological research. Sherrington and his followers have succeeded in building knowledge of function level by level, on Jacksonian principles, from the lowest towards the highest, reaching up towards those at which functional activity is, more or less, associated with consciousness. Sherrington has summarized in his Rede lecture the extent of physiological achievement and outlined the gap between physiology and psychology. That gap is still so wide that it is beyond imagination to pass it. Yet physiological experiment has confirmed Jackson's view that the nervous system from first to last is a sensorimotor arrangement, in which, at higher levels, there is re-representation in ever-increasing complexity of all parts and functions already represented. Physiology has shown, too, that much response may be unseen. Inhibition is equally important with excitation, and it follows, in Sherrington's phrase, that to refrain from an act is no less an act than to commit one.

The variability of function at forebrain level is indeed bewildering. Even in the excitable motor cortex, where functional pattern is relatively stable, it is evident that response depends upon recent individual experience. Stimulation of a point may determine now flexion, now extension, of the same digit. Which will happen depends upon what has *just* happened, not only at this point, but in the sensory cortex behind it.

At higher levels, in Sherrington's words, "The observer, not knowing what twists individual past history has given to the activity patterns of the new brain, may be at a loss to foretell, from minute to minute, what the animal may do. Contrasting this with the predicability of simple reflex action, he may judge that here the reflex principle is departed from. But under true reflex action the same entrant signal may do now one act, at another time another. . . . The issue depends on the amounts of inhibition and of excitement obtaining at the time. . . . But indeed what right have we to conjoin mental experience with physiological? No scientific right, only the right of what Keats . . . . dubbed 'busy common sense'. . . . Science, nobly, declines as proof anything but complete proof: but common sense, pressed for time, accepts, and acts on acceptance" (1937).

The neurologist conceives the nervous system, even at forebrain level of complexity, governed by the same principles as obtain at spinal segmental level. There the rule is afferent impulse and response by excitation or inhibition, but even at the spinal level subliminal excitation and inhibition, unseen but legitimately inferred, determine complex variety of response. Long circuiting at the higher levels allows more and more opportunity for delayed reaction, and so for the interplay of impulses seemingly remote in space and time. With such evidence before him the neurologist approaches the study of mental disorder prepared for what indeed he finds, no fixed clinical syndromes, but types of reaction roughly and arbitrarily defined, with, in the individual patient, inexplicable vagaries of response.

Whether neural activities are associated with consciousness is not the neurologist's prime concern, nor can the phenomena of consciousness be described in terms of physiology. They must be observed and analysed in terms of subjective experience. The neurologist, however, may use opportunity to observe at what levels of reflex activity consciousness becomes active. The control of micturition offers an example. It has long been known that in the adult human subject rhythmical fluctuation of intravesical pressure occurs from contractions of the muscular bladder wall. Denny-Brown and Robertson (1933) have investigated this more fully, and have shown that these fluctuations of pressure occur from time to time as the bladder is filled, and also at intervals if the intravesical volume remains constant. These muscular contractions when of moderate degree do not proceed to the natural end of evacuation, but are suppressed without conscious sensation or volition, a sequence which may occur repeatedly. But, if convenient opportunity makes itself felt by other channels, conscious desire to micturate arises, accompanied by vigorous increase of vesical contraction, and micturition at will. Conversely, when the intravesical volume reaches a certain degree, the magnitude of rhythmical contraction of the bladder musculature is increased to a point at which there is sensation of the desire to micturate. Now if the opportunity offers, micturition occurs at will. But, if there is no convenience, desire is suppressed, rhythmical contraction falls in magnitude to unconscious level, and is again from time to time unconsciously inhibited. Thus reflex activity in the bladder is more, or less, associated with, and influenced by, sensorimotor activities at higher levels, and with consciousness. Left to itself the bladder would (and does when separated from the brain) evacuate its contents automatically from time to time. When its nervous connexions are intact, at low or moderate volumes restraint is unconscious. At higher volumes restraint is *initiated* by conscious activity but is *maintained* thereafter at unconscious level. Restraint, though unconscious, can be removed at any moment by conscious activity. Here it seems are phenomena which might have been described in terms of psychological theory—conflict at an unconscious level, repression, suppression, and, through emergence into consciousness, katharsis.

The advantages of representation of micturition at high level of integration are manifest for saving time and efficiency. But, as with all high-level activities, individual experience determines the final pattern of behaviour. The infant learns to exercise control by adult rule, and there is a stage at which it seems that brain and mind are for the moment largely absorbed with this activity. In the adult control is automatic and unconscious. Yet in the adult when higher cerebral levels are for the time being out of action we may observe behaviour that in no way differs from the infant's. Take, for example, a man after head injury showing no evidence of consciousness except response to painful stimulus. Fidgety movements are an indication to the nurse to apply the urinal, and the act of micturition is performed. The skilled nurse thus will keep a semicomatose patient dry. For the moment again almost

all the brain there is seems to be used for this act. How much mind is another question.

There is another observation in the paper I have quoted which is of equal interest to neurologist and psychologist. We have seen that evacuation of the bladder is restrained by inhibition operating at unconscious level, and that this inhibition may be removed (inhibited) at will. But under circumstances depending upon individual experience willed inhibition may again be inhibited. One of the subjects of the experiments was quite unable at any time to increase bladder contraction at will, being unused to performing the act of micturition in the presence of others. Here there is yet another factor depending upon experience probably forgotten. I should prefer not to speak of unconscious experience. Unconscious activity for the neurologist means physiological activity and no more. Unconscious cerebral function has meaning, unconscious mind has, literally, none. But that conscious experience may be forgotten and yet have left its imprint on pattern of behaviour makes sense.

This glimpse of micturition will serve as example of the neuro-physiological approach to a simple problem of behaviour, and helps to put in perspective the phenomenon of consciousness. For the neurologist, as Cobb (1936) puts it: "consciousness is not a philosophical concept nor yet a matter of definition: it is a function of the organism in action, just as much as contraction is a function of muscle, and the evidence for the former is just as convincing as for the latter. . . ." At what level or levels, physiologically, or even anatomically speaking, consciousness may appear is a problem unsolved, but it seems possible that activity as low as thalamic level may be attended by crude sensation.

The psychologist may ask at this stage whether the neurologist from his study of micturition has anything of practical value to offer to the investigation and treatment of disordered function. He will probably admit contribution if the disorder be "organic" but may deny it if "functional". Here we are faced with a division which for medicine has become a source of much error and confusion. It is in part due to double usage of the terms. "Functional" for some means disorder of a kind which has never been proved due to demonstrable lesion. For others it means mentally as opposed to physically caused. Neither distinction is wholly valid. Disordered function not yet traced to demonstrable lesion may be so traced to-morrow. We have no right to speak of mental *or* physical causes. We can at most say that certain causes operate at levels of neural integration usually attended by consciousness, others not.

There is another meaning sometimes given to these terms functional and organic which has more validity—disorder of the former type is reversible, of the latter not. But it would be better to say so, implying in each instance physical change. Physiogenic and psychogenic are terms which have better value as indicating factors in *causation* to be described respectively in terms of physiology and psychology, but it should be understood that the distinction is made for convenience in description only, and that all cerebral activity whether conscious or unconscious must have its physical basis.

To the interpretation and treatment of disordered micturition whether reversible or irreversible, more physiogenic or more psychogenic, the neurologist can apply physiological principle—to nocturnal enuresis for example. If, as commonly, the story is that of adequate but unsuccessful attempts at training, it is reasonable to suppose defect of unconscious inhibition, a constitutional or congenital flaw in the mechanism. In some cases associated defect in fusion of the vertebral arch strongly suggests this. But, as we have seen, conscious inhibition can reinforce that which is unconscious, and, with repeated exercise, become unconscious too. There is therefore much in reserve. The instruction to the child is to see how many times in the day he can say "No" to his bladder, with the promise that this practice will eventually ensure no emptying without a conscious "Yes". This does not imply neglect of other factors, physiogenic or psychogenic. Too full a bladder at bed-time may be important, also laziness and defeatism. This naïvely simple approach would not deserve mention were it not that its success is equal, I believe, to the more tortuous methods of the analytic psychologist. Physiological hypothesis also allows the patient a "something wrong" which is objective. This, too, helps the physician in treatment; he has a target at which to aim.

The study of micturition, as I have taken it, offers example of the advantage gained by neurophysiological approach. I submit also that the routine examination of the nervous system—sometimes belittled by psychologists—is an essential part of inquiry into the nature and causation of mental disorder, if only because it is a means of discovering, within limits, defect at one level or another of the sensorimotor apparatus, which

is the substratum of integrated behaviour, whether attended by consciousness or not. The neurologist's question, so to speak, is: "What is wrong with the works?" An association of spastic lower limbs with explosive and inappropriate laughter has, for example, simple significance. Often enough the examination will be negative, negative doubtless sometimes because we know not what to look for. The extensor plantar response was discovered half a century ago. How many persons with disseminated sclerosis before that era might have been, and doubtless were, dubbed "functional"!

Neurological examination reaches by psychiatric standards not very far up: nevertheless far enough up for mutual interest. A woman secretary, as first evidence of mental disorder, arrives at her employer's house at 9 p.m., is admitted, goes to her office and begins work. Questioned as to her unusual behaviour she insists that it is 9 a.m. and the ordinary time for starting work. Neurological examination reveals a frontal tumour. Another young woman develops attacks of compulsive thought and utterance. Neurological examination shows that her brain has been damaged by the virus of encephalitis lethargica. I have taken common examples.

It is true that attempts at localization at the higher levels of cerebral function have yet contributed little to the understanding of mental disorder. A man deprived of one frontal lobe may show little alteration of mental function. Nor does it seem to matter much to the character of mental symptoms, if present, whether it is frontal or temporal lobe which is lost. It would seem as though at these levels, so vital for competitive existence, nature has generously provided reserve. There are observations to support this view. Though a lesion of a certain size and situation in either hemisphere alone may produce no disorder, the smaller sum of two lesions, one in each, is often catastrophic in its effects. Another example is severe generalized damage to the brain from trauma. Assume the patient to have recovered so that neither we, nor he, nor his relatives can discern any abnormality of mental function. A year or two later he suffers injury, similar in kind and degree. This time he remains permanently altered; defective in memory, judgment, and emotional control. This sequence has occurred often enough in my experience to suggest that the reserve network was, so to speak, used up in restoring function on the first occasion.

If his examination is negative, the neurologist has at any rate gained something—a basis for inquiry confined to higher levels. His method of approach has the advantage that it begins by being objective. "How far," he says, "can I explain the illness in terms of physiogenic cause? If not completely, can I find psychogenic cause? If neither, I must begin the inquiry afresh with open mind, starting again at the objective level".

It is also, perhaps, an advantage to the neurologist that he approaches his clinical problems with two other questions prominent in his mind. "Where is the trouble?" and "What is its cause?" This dual method of clinical inquiry is, of course, no neurological monopoly, but for the neurologist probably more often than any other worker in the clinical field, hard experience has enforced the rule that the symptom and sign depend rather upon localization than pathology. A right-sided weakness with extensor plantar response and aphasia may, for example, be due to vascular lesion or tumour; or, on the other hand, to reversible disorder, migraine, or post-epileptic phase. The clinical signs are the same.

The neurologist thus approaches mental disorder ready to accept the occurrence of a particular and complex clinical syndrome from quite different causes, the pattern being determined by the level at which disorder has occurred. He will not be surprised, therefore, when he encounters a state of mental depression directly following in one case bereavement, in another a head injury.

Central Pain

Foremost in the symptomatology of all disease is disagreeable sensation, ranging from specific localized pain to general malaise. Every clinician is concerned with the interpretation of such sensations generally, and especially in his particular field of interest. The field of the neurologist differs from others in this respect, that his experience is largely of disagreeable sensation arising from disease within the nervous system. Pain arising from central nervous disorder is a phenomenon worth scrutiny. I shall consider three examples with which every neurologist is familiar, the thalamic syndrome, causalgia, and the phantom limb.

The thalamic syndrome is the most striking example of disagreeable sensations caused by central lesion. These sensations are continuous, and are usually described in terms

which have vague resemblance to normal sensation, though the sufferer can distinguish well enough between the varieties of his own sensations, which are for him specific. Associated with these spontaneous sensations there is always some degree of impairment for normal sensation in the affected parts—a raised threshold. But stimulus which surmounts this threshold—for example, wide stroking contact—causes sensation which is abnormal in several respects. It is intensely painful, radiates far beyond the area stimulated and persists abnormally long. It has been suggested, in explanation, that in the thalamus is localized the function of crude sensation, and that the abnormalities described are release phenomena in the Jacksonian sense. However this may be, we have example of spontaneous pain due to central disturbance, and of sensations in response to stimulus which depend little upon the quality or quantity of stimulus, but much upon the central state of feeling.

Causalgia at first sight might appear a simpler problem. The origin is incomplete lesion of sensory nerve, usually median or posterior tibial. It is characterized by pain of burning quality referred to the appropriate distribution, and, with this, over-reaction to effective stimulus of the same kind seen in thalamic lesions. But there is more than this. If the individual is, as we say crudely, of sensitive type, and especially if pain has persisted long and has disturbed sleep, we know from experience that section of the sensory nerve above the lesion, though it abolishes sensation, may fail to alter quality, distribution, and intensity of spontaneous pain. We can hardly escape the conclusion that intense and continued stimulation from the periphery has caused disorder in the mechanism of sensation at higher levels, which persists even when the stimulus is removed. Certain observations support this view. First, success in the treatment of causalgia depends as much upon the re-establishment of normal feeling tone at the one end, as upon removal of irritant scar at the other. In a great many cases sedatives, hypnotics, occupation, and re-education in the larger sense, will by themselves effect cure. Second, after, and sometimes long after, recovery, disturbance of feeling tone may be associated with return of pain. Such disturbance may be of gradual onset and persistent—a phase of anxiety or depression. It is even more striking, however, if sudden and transient. A man with a posterior tibial nerve injury developed causalgia from which after some months he completely recovered. He was of the sensitive type—and if I ask myself what I mean by this I think it is that there is a tendency for feeling tone, or affect, together with its associated visceral changes, to be more easily roused, rise to greater intensity and persist longer, than in most people. After he had been free from pain for several months he reported momentary recurrence on two occasions. On the first, he was driving his car fast when a waggon emerged suddenly from a field gate. He swerved and avoided accident by a hair's breadth. On the second he was rock climbing, missed a hand-hold and for a moment thought he would fall. On each occasion his pain, though transient, was characteristic in quality and distribution.

The phenomenon of the phantom limb provides a further example of disagreeable sensation centrally determined. The painful phantom, I believe, most commonly follows amputation by trauma, or by operation in emergency conducted with less delicate handling of the nerve trunks than is usually possible. The following example is characteristic. A woman of 40, eighteen months before I saw her, had had an amputation through left mid-thigh for sarcoma of the femur. Immediately following the operation she felt the painful phantom. "The phantom is in a position of flexion at the knee. This appears to be maintained by tonic muscular spasm, which is itself painful. The worst pain, however, is in the foot and of a burning character. At first when she sat up in bed the flexed phantom would appear to hang downwards as if through the bed. Two operations have been performed for relief of pain — resection of stump of sciatic nerve, and subsequently resection of anterior crural. Neither of these has made any difference to the pain, but on each occasion following the operation there has been some change of posture in the phantom. This change of posture ultimately gave way to the original posture, which persists." I have quoted this incomplete note as it stands. It will serve to illustrate my point, which is that, whether by reason of overwhelming afferent stimulus at the time of amputation or for other cause, the central mechanism of sensation seems in these cases to have been disturbed. I have seen another case of painful phantom following lower limb amputation, in which secondary deposit ultimately caused compression of the spinal cord with total loss of movement and sensation from the axillæ down, and yet the painful phantom persisted unchanged except for transient alteration of

posture. Here, then, are examples of profound and persistent disturbance of feeling tone dependent upon central nervous disorder. In the first instance—that of the thalamic syndrome—the cause is demonstrable, a structural lesion, at, or near, the level of feeling. Causalgia and phantom limb we cannot explain in terms of any known pathology. We must have recourse to the hypothesis, already suggested, that physiological stimuli, of normal kind but excessive degree or duration, may result in persistent disturbance of function at higher levels. This disturbance may be manifest in spontaneous pain alone (phantom limb), or in spontaneous pain together with an excessive response to appropriate peripheral stimuli (causalgia).

Physiologically considered the syndromes of thalamic lesion, causalgia, and phantom limb are variants of the same theme. Pathologically considered the first alone has substance, but the physical reality of disease nowadays no longer needs proof by morbid anatomy. As the result of excessive physiological stimulus central derangement occurs, persisting after the stimulus is removed or cut off. There is legitimate comparison here with phenomena described as psychogenic. As the result of excessive psychological stimulus, for example, terror, a state of fear may persist long after cause for fear is removed, and in this state there may be over-reaction to appropriate stimuli from without. The original stimulus may have been excessive in degree or duration. Such persistent disturbance of feeling tone is most likely to occur in the individual of that same sensitive type who is liable to causalgia.

We may carry comparison a stage further. A persistent state of fear may sometimes result not from psychological stimulus, but from cerebral trauma or softening. Here we have feeling tone disorder, of psychogenic type, caused by central lesion, comparable with the disorder of physiological type caused by a lesion of the thalamus.

Affective Disorder

Discussion of feeling tone leads to the neurological aspect of what is known as the affective disorder. I shall say at once that I do not like this term, though it does represent an advance from manic-depressive insanity. One of my difficulties lies in the interpretation of affect. If it means feeling tone I would regard affective disorder as adequate. Henderson and Gillespie (1940), however, use it as synonymous with emotion and in the next sentence observe that emotion and feeling tone are not the same. Feeling-tone-disorder would be a cumbrous title; affective disorder will serve. What I would emphasize is, that what is known as the affective disorder, is on the conscious side alone much more (or it may even sometimes be less), than a disorder of mood; it is a disorder of feeling tone in the widest sense, including mood, somatic, and visceral sensation.

As there are still divergent opinions upon the subject I had best begin by making plain my conception of the affective disorder. I agree with Mapother and Lewis (1937) in including all mental disorder, major or minor, in which disturbance of feeling tone is persistently the central feature. The definition is, of course, arbitrary, as must be the case in symptomatological grouping. It will include at the one end of the scale all that has been called manic-depressive insanity, and involutional melancholia; and at the other end states of depression and anxiety, or fear, commonly called neurotic or psychoneurotic. I accept, of course, the usefulness for practical purposes of distinction between major and minor degrees of this, as of other mental disorder.

It is interesting to note in this connexion how many different criteria have been established by psychiatrists for the distinction between psychosis and neurosis, each of which is infallible for its advocate. Such diversity of opinion in itself suggests that no absolute distinction exists. This is the conclusion reached by Mapother and Lewis, who state: "The distinction between neuroses and psychoses is at times convenient but without substance". Ross (1935), on the contrary, in his Morison lectures, insists on the importance of absolute distinction between psychosis and neurosis, and admits no difficulty. He says: "I shall not here attempt to distinguish between sanity and insanity because, except when we are debating for pleasure, we all know the difference quite well". For myself I have no objection to distinctions between neurosis and psychosis for practical purposes of classification, so long as these are not allowed to obscure scientific classification.

Of the essential unity between the most severe and mildest degrees of the affective disorder I have no doubt. The arguments against drawing any qualitative line between affective neurosis and psychosis are many, and have been ably stated by Mapother,

Lewis, Curran (1937) and others. There is one, however, which I have not found mentioned. It is, I submit, not very difficult to find a patient in a state of affective disorder with marked diurnal fluctuation of degree. In the morning he may show all or most of the features called psychotic: in the evening unbiased observation may reveal features which by the same standards must be called neurotic. Is this patient, then, suffering from two separate diseases, one in the morning, the other in the evening? Such assumption would, of course, be absurd. To the possibility of arriving at any useful or valid distinction for practical purposes between affective psychosis and affective neurosis I shall return later. For the time being I shall use these terms to indicate severe or mild degree and no more. I wish now to invite consideration of the affective disorder as a disorder of the central nervous system at a hypothetical level, at which there is representation of feeling tone, and, together with this, direction of the vegetative functions. That such a level exists is suggested both by common experience of the close association of affective and vegetative disturbance, and by the physiological researches of Bard (1928, 1939) and others upon the hypothalamus.

For the appreciation of disturbance of feeling we must depend upon the sufferer's capacity for introspection as well as upon our own. Opportunity for detailed observation, therefore, is greatest in the milder cases, when the patient is capable of comparison and discrimination.

Disorder of feeling tone is most obviously manifest in change of mood—depression, fear, anger, elation. There is room for much admixture and variety. No less remarkable than variety is occasional specificity of disagreeable feeling. We are familiar with all-embracing depression or fear. Fear state I should prefer to anxiety state, for what is anxiety but fear spread out thin? The sufferer commonly complains of a vague sense of depression or panic. But depression may be more specifically described as, for instance, a sense of guilt, "as if I had committed a crime, although I know I have done nothing of the sort". Fear, even more often, may be specific in the shape of phobias.

On the somatic side I would emphasize the frequency of general malaise, which is described as resembling the experience of infective illness, and also sensations of fatigue. These last are worth brief consideration. Little attention has been given to the neurotic's complaint of fatigue. He is told that sensations of real fatigue are natural and self protective, and that they are rapidly abolished by rest. But unbiased hearing leads me to conclude that the sensations described are identical with those which we all sometimes experience. They may be sensations of mental fatigue, or of physical fatigue, the latter including muscular aches and pains of the kind a man experiences after exercise without training. If we consider the affective disorder as a disturbance of function at the level of feeling, these symptoms are surely no more remarkable than the complaint of the patient with a thalamic lesion that he feels his finger-tips being crushed. They are not, of course, being crushed at all. Nor is the man with the affective neurosis fatigued. Both, as the result of central disturbances, have specific, though different, sensations of discomfort.

Disorders of special sensation are commonly recognized in the psychotic cases, highly compounded, as hallucinations. Giddiness is a disturbance of special sensation which may sometimes be the leading complaint in affective neurosis. It is described as a continuous sense of insecurity or disturbed balance. There is no actual swaying or falling, but the sensation is worse when standing or walking, and especially if walking without support or potential support. It may be continuous for months, disappear together with other symptoms on recovery, and recur in subsequent phases of similar illness. Analysis has convinced me that this sensation of disequilibrium in no respect differs from that sometimes encountered in labyrinthine disease. If you are prepared with me to regard the affective disorder as a central disturbance of feeling, we need be no more surprised at the occurrence of disequilibrium than any other dysæsthesia. We shall at the same time be spared the pains of attempting fantastic explanation of such feeling as symbolizing fear of moral falling.

Disagreeable sensations referred to the viscera also are common without any corresponding disturbance of visceral function, sense of palpitation, for example, without alteration of cardiac rate of rhythm.

I have taken some positive symptoms at random. Together with these are negative symptoms, as we should expect. There is the loss of feeling of well-being and confidence, loss of affection for others, loss of feeling of reality in self and surroundings, loss of feeling for smells and tastes, loss of sexual feeling, and of the natural "calls" to

micturition and defæcation. All these are commonplaces. I would not weary you with them except to emphasize warrant for the assumption that the affective disorder corresponds so far with neurological conception of disorder at level of feeling tone.

With the affective disturbance there is commonly associated disorder of function throughout the sphere of activity directed by the vegetative nervous centres—sleep disorder; altered metabolism; tachycardia; abnormalities of secretion and motility in stomach and gut; alteration in sweat, and body odour; nutritional changes in skin, hair, and nails. We have, I believe, no ground for assuming that these changes are secondary to the symptoms of feeling disorder. They are associated with them, however, so frequently, that it seems that the disorder of nervous function includes that of vegetative control as well as feeling tone. This should not surprise us when we consider how closely associated are these functions in health.

It is instructive to note in passing that for centuries sleep was regarded as a mystic phenomenon, or at least an occurrence to be described in terms of mental rather than physical processes. Now it is known that it is controlled by a compact and localized mechanism in the hypothalamus. When this is disturbed sleep is disordered.

In many cases of affective neurosis disturbances of vegetative function may predominate; and in others somatic or visceral dysæsthesiæ. The leading symptom therefore may be, for example, sleep disorder, dyspepsia, fatigue, giddiness, or headache; with mood disturbance in the background. Hence so commonly the patient's complaint of headache, with the observation that his headache makes him feel depressed. The interpretation of the psychologist is often the reverse, that his depression is causing the headache. I believe the truth to be that headache and depression are associated symptoms of the affective disorder.

Psychosis and Neurosis

I shall now return to the problem of distinction between affective psychosis and neurosis, and consider at the same time the possibility of distinguishing at the lower limit between affective disorder and normal affect. I prefer to take the latter problem first.

If we begin with the assumption that affective illness is the expression of a central nervous disorder we should, before concluding that a patient is suffering from that disorder, exclude adequate peripheral cause; just as in the case of a patient with a thalamic lesion we should make sure that his finger-tips were *not* being crushed, before we concluded that this sensation was centrally determined. But what is adequate cause for affective reaction of specific kind and degree? How long, to take crude examples, and in what degree, should a man feel sadness after bereavement, or fear after narrow escape from bomb explosion? So many conditions are involved, and so many qualifications needed, that questions of this kind can hardly be answered. All we can say, after the most careful inquiry in an individual case, is that considering all the circumstances, physiological as well as psychological, the affective reaction is more, or less, severe and persistent than we should have expected in the "average" person. In studying the reaction itself we must take account, in relation to intensity and duration of stimulus, the ease with which the reaction was produced—that is its threshold—its intensity, and its duration. Of these, duration is alone measurable, and it is the unduly persistent duration of affective disturbance, in relation to other factors, which provides the most conclusive evidence of central disorder. We should include as evidence of such disorder visceral disturbance, for example tachycardia, as well as subjective statement of feeling.

We might, of course, take as our standard not the "average" person but the "ideal" person, and argue that in the case of brief stimulus of whatever intensity, affective disturbance should cease when the stimulus is withdrawn. Persistence of affective disturbance would, in itself, then be evidence of central disorder. War experiences provide many examples of the difficulty of distinguishing between what should be regarded as pathological, what normal. The line is arbitrary, and yet for practical purposes useful. If, for example, a man who is blown off his feet by a bomb without bodily injury, recovers from the affective disturbance within a few days, we may regard this as affective disturbance within normal limits; if it persists for longer than a week we might consider him suffering from affective neurosis. The longer the duration the more likely it is that he will prove to have been always a person of the sensitive type, that is to say, with a tendency for feeling tone, together with its associated visceral manifestations, to be more easily roused, rise to greater intensity, and persist longer than in most people. Sensitiveness with this meaning is closely associated with liability to affective disorder.

Many attempts have been made to differentiate between affective psychosis and neurosis. They have been ably reviewed and criticized by Curran who concludes that there is no sharp division. Rogerson (1940) argues that the severity of the illness, as measured either by degree or duration, offers no valid means of distinction, but that an essential difference between neurosis and psychosis is that the former is not only precipitated by real situations, but kept going, so to speak, by the "preoccupations of the patient, themselves related in a proper manner on the one hand to external reality, and on the other to his instinctive strivings". The psychosis, on the contrary, whether precipitated or not by external situation, has momentum of its own. This distinction implies ability to discriminate between central and peripheral quota of causes, to decide whether sadness (endogenous) is responsible for sad thoughts or sad thoughts (exogenous) for sadness. It is true that, at the most severe end of the scale, the person who is so completely absorbed in his misery as to be inaccessible is presumably anæsthetic to external happenings of a kind which might cause affective reaction, and it may be assumed, therefore, that the affective disorder is independent of outside stimulus. But in the less severe degrees of the disorder there seem to be two elements. There is spontaneous pain—sadness, which in itself tends towards appropriate preoccupations. There is also a lowered threshold for certain kinds of stimulus, with abnormal intensity and persistence of reaction when roused. What kinds of stimulus will depend partly upon the kind of affective disorder (and, as I have noted, mood disorder may be highly specific), partly upon the past history and present circumstances of the individual. External happenings are more or less effective in determining fluctuations of the illness, depending upon a number of factors, including some which are centrally determined. We might roughly compare causalgia.

As so often in psychiatry, therefore, the distinction is "more or less", not "either or". Rogerson himself admits this, yet goes on to define the neurotic as having causes analysable in psychological terms, sufficient to account for his depression, "which is, therefore, only *apparently* disproportionate" (the italics are his). Later in the same paper he states: "The neurotic may complain of depression for which he cannot find a cause, but preoccupations will always be discoverable based upon reality, which have a cause and effect relationship to the depression". This tendency to force the issue is common to all attempts to impose qualitative distinction between affective neurosis and psychosis. I believe it true that in the milder degree of the affective disorder preoccupations will always be discoverable which are the product of central disorder and external stimulus in varying degree. It is common to find the patient depressed and anxious over real difficulties, some of which may have been shelved or forgotten. It is easy then to assume that the affective disturbance is wholly dependent upon peripheral cause, but unbiased scrutiny will very often reveal that these same difficulties have existed before the illness, and that the patient did not become depressed or anxious over them until he became ill. A patient of mine, for example, was depressed and anxious over his income-tax returns which for some years had been falsely stated. He feared discovery and punishment. His accountant confirmed the basis for these fears, and was, indeed, so perturbed at what he discovered, that he refused to act for him any longer. This state of affairs, however, had existed unchanged for some years, during which the patient had been quite happy. It did not begin to worry him until he developed an affective illness precipitated by quite a different cause—the discovery by his wife of his infidelity. After some months he recovered, and then made light of his financial irregularities. He asserted that he would never be found out, and regretted that his accountant had become aware of the secret. Three years later, without discoverable cause, he became depressed and anxious again with the same preoccupations as before, and again recovered. During each of the phases of illness there came into his mind memories of other faults of omission and commission, more or less related to the central theme, which, when he was recovered, were forgotten.

Rogerson's distinction is, however, within limits, useful in its implication of therapeutic possibility. There are patients with mild affective disorder, whether phasic or continuous who, though they are not normal (and know it), when things go well for them may pass for normal to the outside world, do without doctors, tread the usual path. But if things do not go so well for them, or if, in other words, they fail to deal adequately with their difficulties, they develop symptoms which as Rogerson aptly phrases, "are as it were a running commentary upon this failure". Here, of course, is opportunity for psychotherapy to develop an improved technique of living, and by so doing to remove symptoms.

Another distinction of practical value is that proffered by Adolf Meyer, for mental disorder in general, between holergasia and merergasia. There is an important difference in degree between the illness involving the whole person, and the illness leaving some part of the personality free. In the merergasia we see not only the illness, but the patient's attempt, in terms of what he has left, to react to it. What is left, and therefore the mode of his reaction, will depend upon a large number of variable factors, his heredity in respects other than the affective disorder, his training, experience, circumstances, and prospects. Hence a variety in the clinical picture of the merergasias which is as great as there are numbers of individuals. I believe it is this superficial variety in the clinical features of the merergasias (affective neuroses) that has been partly responsible for making it hard for some psychiatrists to see the fundamental unity with the holergasias (affective psychoses). In the latter there is nothing to be seen except the illness, whose outlines are reasonably clear and constant. In the part reactions, form is variable and outline hazy, with dependence upon, and alteration with, environment, of a kind which does not obtain in the whole reactions.[1] If, therefore, in discussing the affective disorder, we are going to make any use at all of the words psychosis and neurosis, I should prefer it to rest upon the basis of whole, or part, involvement in this sense, with due recognition that the division is arbitrary and quantitative.

Causes and Treatment

In the ætiology of the affective disorder there is evidence that inherited disposition plays an important part. If it be conceded that neurosis no less than psychosis demands inclusion, statistics need to be revised, but I believe that they will point in the same direction.

Apart from heredity there is little known of cause. What is important, perhaps, is that precipitating cause when definite may be so various — emotional disturbance, infective or toxic illness, fatigue, or head injury. This to the neurologist is not surprising, for he is accustomed to different causes operating at the same level producing the same symptoms. What is indeed remarkable is the absence of apparent cause in so many cases, and I suspect this is equally true of neurosis and psychosis, though harder to prove in the neurotic, who tends to rationalize his illness. There is generally some cause for depression or fear, or even for elation, in the background of a man's mind. The neurotic, once he becomes ill, becomes preoccupied with whatever memory suits his mood, and is easily convinced that the preoccupation is causal.

Causeless onset in a disorder of this kind is at the same time a reminder of our ignorance of cerebral function, and of the almost infinite variety of combinations made possible by the cerebral nerve net. Time itself may be an ætiological factor. We have reason to conclude from Pavlov's experiments that each minute of the twenty-four-hour cycle has its own physiological value. How else could the dog, in uniform surroundings, be conditioned to salivate at a fixed time? May not each minute of the life-cycle also have value to determine balance, and direction of excitation and inhibition, and so precipitate a phase of illness? Life-histories in certain cases suggest this.

What perhaps is even more noteworthy is that the affective disorder can persist so long and yet be so completely reversible. There can, therefore, be no structural alteration of a kind we should call lesion, and it is possible, if not probable, that there is a cause outside the brain itself—physical or chemical.

However that may be, it seems that in certain persons once the points are set in a particular direction there they stick—till something happens—usually it would appear the passage of time. But this cannot be all. A man with a family history of the affective disorder became ill with depression, not of completely disabling degree, at 25. For fifteen years it continued at fairly even level; then at 6 o'clock one evening the cloud lifted. He felt his old almost forgotten self, his expression and bearing changed, his wife coming in recognized him as a new man. The respite lasted for an hour. His condition then was as before and had remained so for a year before I saw him. He was possessed of intelligence and riches, and had used both in the utmost endeavour to discover cure. The most careful investigation by means of physiological and psychological analysis had failed to reveal any cause either for remission or relapse. Needless to say my name was added to the list of failures.

[1] This distinction is true of pain in general. If pain is maximal and all-absorbing the clinical picture is little subject to variability, and the converse also is true.

What is that something which makes a difference, that can reverse the points? Probably chance combination of countless happenings. Is there any short cut to cure of this illness, and, if not, what treatment is there? I know there are many ready to reply, that for the psychotic there is no short cut, and the only treatment is care, and for the neurotic (suffering from a different illness altogether) psychotherapy will affect cure. I believe neither of these statements to be true. What *is* true, as Curran and others have stated, is that this illness whether of psychotic or neurotic degree in most cases tends to recover in its own time. Figures showing the results of psychotherapy by different methods need, therefore, to be checked against control material, as well as against one another, and duration of illness both in treated cases and controls should be taken into account. When this is properly done I believe the net results of psychotherapy in the affective neuroses, as measured by percentage of recovery and duration of illness, will not amount to very much. I do not imply that psychotherapy is useless, far from it (though certain forms of psychotherapy, I am sure, do harm). What psychotherapy *can* do for the affective neurotic is to help him make the best of his illness while it lasts (and it must be remembered that it may last all his life). This may mean a great deal. It may save him from suicide; it may save him from losing his employment; it may make a great deal of difference to the happiness of those around him. It may sometimes help him, if the illness is phasic, when he recovers, to avoid recurrence, by acquiring a better technique of living. When I say that psychotherapy may do these things, I am, perhaps, guilty of misstatement and mean psychiatry, for I include management (of patient, friends, employer), medical, and sometimes surgical treatment. Even focal sepsis is not entirely to be ignored as something which may make a difference on the wrong side of the balance. Sometimes, but I think rarely, psychiatry may accomplish more than symptomatic improvement and may short circuit the illness. It may do so equally in cases of neurotic and psychotic degree—continuous narcosis and convulsive therapy for example. There is much to be gained then from pyschiatry of the right kind. There is much also to be lost from psychiatry of the wrong kind.

I do not seek to belittle the contribution to psychiatry derived from the psychopathology of Freud and his followers. It has shown the meaning of individual symptoms, and proved in certain instances the importance of forgotten experience and unrecognized cravings in contribution to emotional unrest. But my impression is that the analytic method on the whole has been responsible for as much harm as good in the treatment of affective disorder.

It was in one sense unfortunate that the Freudian method of approach scored such an immediate success in the interpretation of hysteria. This led to the false assumption that because hysteria was a neurosis, and because the origin of hysteria was "unconscious" motivation, all other neuroses had similar origin. As a result I dare not guess how many patients with affective neurosis have been subjected to the Analytic Inquisition. I believe it to be as wrong to assume that the symptoms of an affective neurosis are means of evasion or gain, and will disappear when the patient has grasped and acted upon this explanation, as to make the same assumption in the case of a patient with a lesion of the thalamus or causalgia. Yet this is the assumption often made, or at least implied, in psychotherapeutic approach. I do not suggest that this possibility should be excluded. On the contrary it is one which should always be kept in mind. There are many persons who will take of illness what advantage they can, whether that illness be affective disorder or a broken leg, and the habit of invalidism may persist after the disease has ended. This is why the method which I criticize has, in some cases of affective disorder, done good. But I believe there are many more in which it has been carried too far, with consequent aggravation of depression, perplexity, and sense of guilt.

I have no doubt that a hysterical reaction is more often associated with, I would say secondary to, affective neurosis, than a broken leg, and that it is very often defensive. The man with a broken leg has something to show as evidence of disability. The person with affective neurosis may feel so ill that he cannot cope with work or responsibilities, and has nothing to show.

A married woman was once brought to me with the story that, following removal of an ovarian cyst, she had developed paraplegia, which her doctor had rightly diagnosed as hysterical. She came into my room supported on either side by relatives. The full story revealed a state of affective disorder characterized by depression, sense of fatigue, difficulty in concentration, and other symptoms. She had felt unequal to her tasks,

formerly achieved without difficulty, of looking after her household, and keeping her husband's business accounts. She consulted her doctor, who, without realizing the nature of her complaints, discovered the tumour and removed it. When the time came for convalescence, with the prospect of return to work, she felt just as incapable as before the operation. Her surgically minded doctor explained, with no avail, that the tumour had been removed, and she must now be well. She, however, found that her legs would not support her. This story was elicited as the patient lay on the couch, after physical examination had been completed and the relatives had been sent from the room. I then told her that she was suffering from a state of nervous depression which to my mind was just as much a real illness as typhoid fever. She was a sensible woman who described her symptoms clearly. I was interested in them. She was appreciative of understanding and sympathy. We both forgot about her paraplegia. She continued to talk to me about her feelings of depression while she dressed, got up, walked across the room normally, and sat in a chair. No further mention was made by either of us to the weakness of her legs, nor did it return. The affective illness lasted nearly a year, during which she had help in her home, and more sympathetic treatment from her doctor. She ultimately made a complete recovery.

This I offer as a common—it happened to be dramatic—example of the fact that, if the true nature and measure of the disability in affective neurosis are disregarded, hysterical symptoms may be engendered. I have seen hysterical disability in cases of affective neurosis which I believe has been engendered, not by simple disregard, but by misguided psychotherapy.

Medical Psychology

Between neurology and psychiatry, or perhaps more truly in another part of the field altogether, there has appeared, during the last quarter of a century, a separate edifice, called medical psychology. It has grown rapidly, and to large dimensions, and has attracted attention and admiration, outside, as well as inside the medical profession. The term psychological medicine is, of course, an old one, and owes its derivation largely to a respect for popular prejudice. Patients with mental disorder, major or minor, are much readier to go to a physician, or department, for psychological medicine, than to a physician or department openly avowing provision for mental disorder. A diploma for psychological medicine also is unlikely to frighten patients away, but a diploma for diseases of the mind might do so. These shifts we may accept as legitimate camouflage. But medical psychology in recent years has implied something more than this. It has been claimed for it that it should be recognized as an independent structure based upon the foundations of psychological training and experience. It is true that the nature of the training and experience required is a matter of much dispute among medical psychologists, and that the syllabus drawn up by one would be critically regarded by half a dozen others. Each would be quite sure that his own syllabus was the right one. They would agree, however, in claiming that medical psychology has sole right to diagnose and treat the neuroses, and therefore to teach on these subjects.

The medical psychologist asserts that for this purpose training in psychiatry is unnecessary, because the business of the psychiatrist is the diagnosis and treatment of the psychoses, and there is no connexion between neurosis and psychosis. I have already criticized this assumption so far as it applies to the affective disorders. What I have said, I consider as being equally applicable to all mental disorder. There are mild and severe degrees, part and whole reactions, but between neurosis and psychosis there is no more than a quantitative distinction. There are many who agree with me, and if we are right, the medical psychologist is obviously wrong; the study of minor and major mental disorder is one and the same thing, and no one can possibly understand the one without understanding the other. The medical psychologist's attitude is, therefore, just as much deserving of criticism as would be that of the specialist in tuberculosis, if he were to state that he would confine himself only to the diagnosis and treatment of cases in which one lung was affected, and that if both lungs were involved, that was a matter for another specialist with two-lung training.

The medical psychologist also asserts that for his purpose training in neurology is unnecessary. He may be prepared to admit that all mental activity has its physical basis, and that brain is the organ of mind, but these propositions are, for him, of theoretical value only. They have no real bearing upon the practical diagnosis and treatment of the neuroses. An approach to these problems in terms of neurophysiology

and neuropathology may be an interesting intellectual exercise, but has no practical significance. I have already attempted to indicate the fallacies in such argument, with especial reference to the affective disorders. I would take as another example the diagnosis and treatment of neurosis following head injury. Here we have a patient whose adjustments to inner need and external stimulus are faulty. How far is this due to inherited disposition, training, experience, present needs and difficulties; how far to the nature and situation of cerebral damage? Is the cerebral injury of reversible or irreversible character? If there is headache, how much is due to meningeal adhesion, alterations in the cerebrospinal fluid pressure or circulation, or disordered cortical rhythm? How much to fear, depression, or defeatism arising from difficulty in coping with the situation as a whole? If there is insomnia, how much is due to anxiety, how much to hypothalamic damage? I submit that the answers to some of these questions are impossible without neurological training, and that unless they are all answered diagnosis and treatment must be at fault. I do not think this is an unfair example. There are many other instances in which knowledge of cerebral function in health and disease, in relation to nutrition—including vitamin supply, effect of drugs, endocrine disorder, or oxygen need—is essential to the proper understanding and treatment of neurosis.

If then medical psychology is insecurely founded, why has it achieved so great distinction? In virtue, I think, of the achievement of certain individual leaders in the movement as healers. The essence of what is called psychotherapy lies in the personal relationship between physician and patient. Success in treatment must, therefore, depend much more upon the personality of the physician than the method employed. But medical psychologists—at least some of them—are modest people. It is not we, they say, who are successful because of our particular qualities of sympathy, wisdom, candour, and courage, it is the technique we employ. Others admiring their success apply themselves to study their technique. Thus schools of medical psychology are founded. The truth is, I think, that there is no justification whatever for psychotherapy as a special branch of medicine. There will always be some outstanding psychotherapists in the profession. They may be psychiatrists, neurologists, gynæcologists, specialists in any branch, or general practitioners. These last have the greatest opportunities. A valuable contribution of Freud and his followers has been their insistence upon the necessity for full examination. It is just as important that the doctor should learn to strip the mind bare as the body, with as little embarrassment, and with as much respect for human dignity and feeling. This truism is, I think, now accepted by those engaged in all branches of the teaching of medicine, and the practitioner therefore goes to his task the better equipped. What success he will achieve in the treatment of the neuroses which constitute so much of his practice, will depend upon his own personality and the principles given him to work on. These should be based upon the broad foundations of clinical medicine, with superstructure of neurology and psychiatry. Above all, let us avoid implanting in the student's mind the false notion that psychotherapy has an elaborate, precise, and time-consuming technique, which must be mastered before its practice is permitted. Competence in this, as in other branches of treatment, is to be achieved only by personal experience, and with the aid of personal experience and a few fundamental principles to guide him, any man who has the qualities of a good doctor can become a sound psychotherapist.

Neuropsychiatry

The leaders in medical psychology have rendered valuable service to neurology and psychiatry (as well as to the community at large) not only by the example of their own success in treatment, but by stimulating greater interest in the early detection and treatment of neurosis. How far, and how long, psychology will maintain its claim to be a separate branch of medicine with care of the neuroses is another question. I think the answer will depend upon the readiness of neurologists and psychiatrists in this country to acknowledge what has already been accepted elsewhere, that, as brain really *is* the organ of mind, their subject is one and indivisible, and that they have common interest and duty in the field of neuroses. There are welcome signs of a tendency in this direction. They are to be seen in the intention to establish wards for organic nervous disease as an integral part of the Maudsley Hospital, and a similar intention to incorporate a unit for the study of mental disorder at the National Hospital, Queen Square.

The need for unity has also been recognized for some time on the psychiatric side by the inclusion of neurological experience in the requirement for the Diploma of Psycho-

logical Medicine, and of papers and clinical examinations conducted by neurologists. More might be done without much difficulty to facilitate union or symbiosis. It should be an indispensable part of the training of an aspirant to consulting status in neurology, that he should hold a resident appointment for a year in a teaching hospital for mental disorders, and equally indispensable for the psychiatrist to have held a similar appointment at a neurological hospital. The title and syllabus for the Diploma of Psychological Medicine might well be revised. It should be called, what it is already in embryo, Diploma of Neuropsychiatry, and the requirement of neurology should be increased on the clinical side. The Diploma then should be an essential qualification before hospital staff appointment no less for neurologist than psychiatrist. Most important of all will be the conjunction of neurologist and psychiatrist at general hospitals to form Departments of Neuropsychiatry. In such departments there will always be room for those whose natural gifts and interests fit them especially for psychotherapy.

Looking to the past I believe that neurology and psychiatry in this country were kept apart at first, because the neurologist was interested in morbid anatomy, and the psychiatrist in the care of the insane. At the beginning of the present century they were coming together when the psycho-analytic wave widened the gap. The neurologists, on their side, perhaps gained somewhat in that their employment on other duties saved them as a group from total immersion in the flood, and they had opportunity to watch from the bank the turgid waters subside into a clearer trickle. At present the gap is narrower than it has ever been. The fruits of recent research and experiment have emphasized common interest, for example the work of Bard and others on hypothalamic function, the contribution of the biochemists to the understanding of brain metabolism, the study of cortical rhythm by the electro-encephalogram, the lessons of continuous narcosis and convulsive therapy. Looking to the future I believe that the merging of the two specialities into one is not only desirable but inevitable.

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Section of the History of Medicine

President—Sir Walter Langdon-Brown, M.D.

[*December* 4, 1940]

The History of Endocrinology

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The literature of modern endocrinology is not only immense in volume but also confusing in its wealth of conflicting opinions. A synthesis of the work should serve to clarify the reader's ideas and bring to his mind a sharp, cogent picture of contemporary endocrinology. This can only be done by a study of its historical development.

Three periods can be distinguished in this historical development. The first or descriptive period, the second or period of analytical endocrinology, and the third contemporary period, that of synthetic endocrinology. Each of these periods is based on certain special directive lines of scientific research, but although they follow each other chronologically in their beginnings there is much overlapping; for instance, even in our own times, research on the lines of the descriptive period is being pursued. This division is thus chronologically correct only as regards the special directive lines of research which appear in the course of the centuries.

First Period

Description of the Endocrines

The anatomical description begins with that of the classical endocrines. The gonads and liver were known to the earliest physicians; the thymus to the Alexandrians (third century B.C.). The thyroid, pineal, and pituitary were described by Galen. The suprarenals were discovered by Bartolommeo Eustachi in the sixteenth century. The pancreatic insula was found by Langerhans in 1869, and finally the parathyroids by Ivan Victor Sandström, of Uppsala, in 1880. I have included the liver among the classical endocrines following Claude Bernard, who introduced the conception of internal secretion in his study on the liver. Although for many years after the work of the French physiologist there is no mention of this organ among the endocrines, contemporary authors have reintroduced the conception of the "endocrine liver". In fact, not only does the liver secrete real hormones, but through its enzymes it is the terminal effector organ of the metabolic functions of the endocrines. It is impossible to understand endocrinology without considering this most important of all metabolic organs.

These are the adult endocrines. They make their appearance in the fourth week of embryonic development, when the embryo is 3 mm. in length. Recently, however, other endocrine organs occurring in the embryo before the appearance of the definite endocrines have been described. These are the "organizers", whose function is to direct development of the amorphous cellular mass represented by the early embryo into differentiated organs. Work on this subject started with Spemann who described the primary organizers as appearing at a very early stage, probably before the beginning of embryonic cleavage, and situated in the dorsal lip of the blastopore, and the secondary organizers which developed a little later, probably under the influence of the primary organizers; these in their turn inducing the formation of various tissues and organs.

J. C. Needham has demonstrated that Spemann's organizers direct differentiation of the embryonic cellular mass through a special morphogenetic hormone, which is a sterol and thus related to the sex hormones, the cancer-producing substances, and vitamin D.

The term "endocrines" has covered a wider field in recent years. It has been demonstrated that all cells of the body possess an incretory function. As early as the eighteenth century Théophile de Bordeu wrote of "emanations" from the various body tissues penetrating into the blood. Brown-Séquard and d'Arsonval in the nineteenth century developed this idea more scientifically. Internal secretion is then a function of all cells. There are cells, however, isolated in various tissues, which possess this incretory power to a higher degree, such as some cellular elements of the hypothalamus and those described in the spinal cord by Speidel. A step forward in the specialization of internal secretion is represented by somewhat loose groups of these endocrine cells constituting diffuse endocrine organs. These were first described by Masson as "argentaffine organ" scattered in the mucous membrane of the gastro-intestinal tract. A similar diffuse endocrine organ is described as spread in the duodenal papillæ and probably secreting the hormone secretin. The research work done on these organs has been reviewed recently by Feyrter.

Thus in this first or descriptive period we see that study of their historical development allows of a synthetic conception of the endocrines. All cells possess an endocrine function. In certain tissues isolated cells become more specialized and constitute incretory cells. One more degree of specialization, and these cells are grouped loosely as diffuse endocrine organs. The highest form of specialization is the grouping of such cells into the real endocrine glands.

Second Period. Analytical Endocrinology

Special Physiology of the Endocrine Glands: the Hormones

Only in the eighteenth century did the idea of an internal secretory function of the organs known to-day as endocrine glands emerge, mainly in the work of Dutch physicians such as Ruysch, quoted in Haller's *Textbook of Physiology* published in 1766. This conception was elaborated by Le Gallois in 1801, but chiefly by T. Wilkinson King as regards the thyroid (1836), and George Gulliver for the adrenals (1840). The first experimental proof of internal secretion came from John Hunter in 1792 and Berthold in 1849. The Göttingen physiologist, completing the experiments of Hunter, showed that castration in the cock caused atrophy of the comb, but that this could be prevented if the testis were transplanted to another part of the body. This experiment demonstrated the influence of the testis on the blood and thus on the body as a whole.

All this was prodromic work. The conception of internal secretion by the glands already described took a definite place in scientific knowledge in 1855, the year called by Dana the peak of endocrinology, through the work of the great triumvirate Claude Bernard, Thomas Addison, and Brown-Séquard. In that year Claude Bernard published his *Lessons on Experimental Physiology*, in which the doctrine of internal secretion is definitely established experimentally. In the same year Thomas Addison published his classic *On the Constitutional and Local Effects of Disease of the Suprarenal Capsules*, in which the rôle of internal secretion is demonstrated through anatomoclinical observation. Lastly, in that same year, Brown-Séquard, stimulated by the work of Addison, made the first experiments in adrenalectomy.

From that time onwards physiological knowledge of the endocrine glands progressed rapidly. Their internal secretion was shown to consist of special chemical substances, the hormones (a term used first by Starling in 1905). One year after the great peak of 1855, Vulpian, physician to the Salpétrière, discovered in the adrenals and the blood coming from the adrenals, a chromogen which he connected with the secretion of these glands. In 1895, Eugen Baumann described iodothyrine as the active principle of thyroid. In 1901 Takamine and, independently, Aldrich isolated the incretion of the adrenal medulla and determined its chemical formula as adrenalin; one year later Bayliss and Starling isolated secretin from the duodenal secretion. With the special tests originating in the work of Stockard and Papanicolaou and the perfecting of chemical technique, work on the isolation, purification, and chemical determination of the hormones is proceeding actively.

The last phase in the history of the special physiology of the endocrine glands is the

discovery of the integration of these glands and of their regulatory rôle in the metabolic processes of the body. Through the work of Harvey Cushing and of Langdon-Brown the endocrine glands have been demonstrated as constituting a system integrated by the pituitary. Active experimental work has shown that this system regulates metabolism (a term introduced by Michael Foster in 1876), that is, the chemical processes of the body. All cells of the body possess special metabolic functions. If these cells worked independently the result would be chaos. The endocrine system regulates, correlates, and integrates all these local cellular metabolisms. It thus contributes to what Claude Bernard called the fixity of the internal environment (the blood and all intercellular fluids), which is the absolute condition of "free life".

The endocrine system appears, therefore, in this phase of scientific work as the system of chemical integration of the body, working in harmony with the system of the nervous integration of the body, namely, the nervous system (including the sympathetic as well as the central nervous system).

Third Period. Synthetic Endocrinology

The Connexion between Hormonal and Nervous Functions. The Neurohumoral System

A new phase of research, which is being actively pursued and has already led to startling results, bears on the connexion between hormonic and nervous functions.

A first series of workers demonstrated that the endocrine glands and their hormonic secretions are under the influence of the nervous system, although they are capable also of independent function.

Anatomists, on the basis of perfected technique, have shown the penetration into the endocrine glands of nervous fibres terminating not only in the vessels but also around secretory cells. The nervous connexions between hypothalamus and pituitary gland—the central endocrine—have been studied and demonstrated by L. Greving (1918), Roussy and Mossinger (1933). Ransom and his co-workers have described a characteristic nerve tract between supra-optic nuclei of the hypothalamus and the posterior pituitary.

Physiologists have shown the influence of nervous stimulation on hormonic secretion. This has been demonstrated by Cannon for adrenaline, by MacLeod for insulin. They have also shown that stimuli applied to various parts of the body induce secretion of pituitary hormones, as demonstrated by the olfacto-gonadal reflexes, optico-ovarian and optico-testicular reflexes, the ovulation reflex, and the opto-pigmentary reflexes. This also presupposes intimate diencephalo-pituitary connexion, and in fact for the olfacto-gonadal and the optico-gonadal reflexes the whole reflex arc has been described anatomically (Roussy and Mossinger).

Finally, clinicians have demonstrated the rôle of emotional factors acting through the nervous system, through cortico-diencephalic connexions in the genesis of hyperthyroidism, hypo-ovarism, and hypo-insulinism.

Clinical as well as experimental proof has been given that many so-called endocrine diseases are due to nervous lesions (Camus and Roussy). Langdon-Brown, synthesizing this work, holds that most of these nervous stimuli act first on the hypothalamus. From this nervous fibres transmit a nervous impulse to the pituitary, which secretes its special or endocrinotropic hormone influencing other endocrines.

While all these workers were demonstrating the intimate connexion between organs of hormonic secretion and the nervous system, others were demonstrating that the so-called nervous function is in fact a neurohormonic function, that the nervous impulse acts through a hormone released at the termination of the nervous fibre. T. R. Elliott first conceived, in 1904, that nervous sympathetic fibres acted through release at their terminations of a special chemical substance, a hormone as we say to-day, and this idea was developed in the experiments of Loewi of Graz (1921) and Cannon (1931). The hormone released at sympathetic fibre terminations has been termed adrenilergic hormone or sympathin. Dixon (1906), Loewi (1921) and principally Dale (1929) demonstrated that the action of the parasympathetic nerves occurs through liberation at the endings of these nerves of a cholinergic hormone. Dale demonstrated that action of the cerebrospinal musculomotor nerves occurs through liberation at their terminations of acetylcholine.

The result of this work was to show that what we called hormonic function was under nervous control, and that what we call nervous function is in fact neurohormonic. Now, even a few years ago the organism, the body-mind, was considered to be so integrated

as to act as a whole through two mechanisms working in parallel, the nervous mechanism rendered effective through the nervous system and the chemical or hormonic mechanism rendered effective through the endocrine system. As the work already described demonstrated that both nervous and endocrine systems act neurohormonically, the immediate result has been to unify these systems into one, the extended nervous system or the neurohumoral system, and thus to include endocrinology in neurology. This trend of thought is emphasized in Sir Humphry Rolleston's standard work on the Endocrines in Health and Disease.

Through the extended nervous system the body adapts itself to environmental stimuli. Its effector component is divided into three sections, neurosomatic, neurovisceral, and neurometabolic (or neuro-endocrine). The neurosomatic component, consisting of what is usually known as the motor cerebrospinal system, regulates movement, this being the result of a nervous impulse originating in various centres of this part of the nervous system and causing at the terminations of the nerve fibres release of acetylcholine, which acts on the muscles. The neurovisceral component, which includes the greater part of what is known as the vegetative system, regulates visceral function, this being the result of a nervous impulse originating in various centres of this part of the nervous system and causing at the terminations of the nervous fibres liberation of an adrenalinergic or cholinergic hormone. The neurometabolic system, which is formed of that part of the vegetative nervous system innervating the pituitary and the other endocrines, and by the endocrines themselves (in fact the old endocrine system), regulates metabolism, this being the result of a nervous impulse originating in the various nervous centres of this system and causing at the terminations of the nervous fibres release of various hormones through action on the endocrines, for the most part through action primarily on the pituitary. This mechanism is similar to that of the other two components of the nervous system, but as regulation of metabolism requires a more diffuse and intensive hormonic action the hormonic element of the "nervous" function has been greatly developed by the appearance at the terminations of the nervous vegetative fibres of special endocrine glands. These may act independently of nervous impulses and may be stimulated via a humoral route, but this does not alter the general architecture of the neurometabolic system.

For all these effector nervous, or more precisely neurohormonic mechanisms, neurosomatic, neurovisceral, and neurometabolic alike, centres are found at all levels of the nervous system including the cortex, as demonstrated by Fulton, to whom much of the development of these ideas is due. The principle of telencephalization, as this author has pointed out recently, should be applied to the whole nervous system and not only to its somatic component. The chief centres for the neurovisceral and neurometabolic systems, however, are situated in the hypothalamus, and to this is due the renewed interest in this part of the nervous system witnessed by two important recent publications, the British edited by Professor Le Gros Clark, and the American edited by Fulton.

The effector centres of the neurosomatic, neurovisceral, and neurometabolic components are actuated by nervous messengers, the ordinary reflex stimuli, by psychical messengers originating in the psycho-associational cortex, consisting probably in elaborated peripheral stimuli, and by chemical messengers consisting in changes of the chemistry of the blood flowing through these centres.

Twenty-five centuries ago, one of the first Greek physicians, Alkmeon of Croton, disciple of Pythagoras, held that the body was integrated as a whole through the hegemony of the brain. His remarkable intuition has been verified by those who have enlarged our knowledge of the nervous system, notably by Gaskell's demonstration of the integrative action of the vegetative nervous system on visceral function, by Sherrington's work on the integrative action of the nervous system, and by the labours of those named in this paper who clarified knowledge of chemical and hormonic integration and presented these two biological mechanisms as a unified whole.

The Nosography of the Endocrine System

The first description of endocrine disease, that is, the first work linking certain symptom complexes with disturbances of endocrine organs, was given long before there was any accurate knowledge of endocrine physiology. It occurs, in fact, in the writings of Hippocrates, who studied hypo-orchidism, the disease of the Scyths, and climacteric hypo-ovarism. Only after some advance was made in the knowledge of glandular physiology, however, were endocrine diseases introduced into nosography. The earliest of these was

hypothyroidism, studied first by T. B. Curling in 1850, when the role of the thyroid in the symptom complex designated as cretinism was shown. This conception of a disease "hypothyroidism" was elaborated later by Charles Henry Fagge in his description of congenital hypothyroidism (1871) and in Sir William Gull's description of adult hypothyroidism (1873). Hypo-adrenalism was described in 1855 by Thomas Addison, and the real start of endocrine nosography was marked by this work.

Since that date other endocrine diseases have been described, and not only have unattached symptom complexes been shown to be linked with endocrine dysfunction but also, thanks to the inclusion of the endocrine pancreas and the endocrine liver in endocrinology, diseases described as "of metabolism" such as diabetes, obesity, and even gout have been included in endocrine nosography. In fact the title of Barker's classical treatise *Endocrinology and Metabolism* is tautology. Diseases of metabolism are abnormal states of the regulators of metabolism, that is, of hormones and vitamins (which are a sort of external hormone).

A notable advance in the therapeutic chapters of the natural history of endocrine diseases was made with the introduction of endocrinotherapy. This began with Brown-Séquard in 1889, reached a notable peak with the introduction of thyroid organotherapy by G. R. Murray in 1890, and developed intensively of recent years. Outstanding events are the introduction of insulinotherapy by Banting in 1921, of the various sex hormones, and of cortin.

The recent developments of endocrine nosography consist in more accurate studies of the physiopathological chapters of the natural history of these diseases. With knowledge of the neurohormonic connexions the extreme, localistic point of view has been abandoned, and these diseases are regarded not always as local endocrine disturbances but frequently as neurohormonic disturbances. Such is the contemporary conception of Graves' disease, for instance, of diabetes insipidus, and of many other "endocrine disturbances". This modified physiopathological conception enlarges therapy. Endocrinotherapy can no longer be considered as the sole method of treating these disorders, more general methods are now advocated, and the rôle of psychotherapy, dietotherapy, physical medicine and certain constitutional medicines is accepted more and more widely. Even endocrine gland surgery is rendered more effective when used in conjunction with general constitutional therapy.

Probably in no other branch of medicine is advance in nosography and therapeutics so closely bound up with increase in physiological knowledge as in endocrinology. With the wider and more synthetic conception of contemporary endocrine physiology a more complete and effective therapy is possible.

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Section of Otology

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[*February* 7, 1941]

DISCUSSION ON THE PSYCHOLOGICAL ASPECTS OF DEAFNESS

Dr. H. Frey: A great part of all the sense impressions supplying us with information about the outer world passes through our hearing organ as an entrance gate. A study of the psychological conditions in people with a defective sense of hearing must therefore be worth while both from a theoretical and from a practical point of view—theoretically, because anything which may add to our knowledge of the conditions of our patients must be important; practically, because it might help us to a better and more complete understanding of their complaints and assist us in alleviating them.

Our literature contains very little about this question. I do not know of any book or even paper dealing exclusively and comprehensively with the whole problem. There are, however, publications treating certain aspects of it, some of which are given in my reference list.

The deaf are not a uniform group. Some suffer from a congenital loss of the hearing function—the deaf-mutes. Others who have acquired their hearing defects in later life are generally known as the "deafened". Not everyone with a hearing defect, however, can be considered as "deaf". For the purpose of this investigation we should classify as "deaf" any person with defective hearing who feels this defect to be an impediment in private or occupational activity or in general enjoyment of life—or, in other words, anyone continually conscious of such a defect. Thus, we make the subjective feeling the basis of our definition.

The deaf-mutes form a separate community among the hearing people.

The most interesting question in their psychology is: What is their conception of the outer world? Of an unacoustic, mute world? The Ewings (1938) say in their book, p. 209: "The word is a kind of shorthand symbol." What is the true character of these shorthand symbols in the deaf-mute's mind? Probably visual. And what would they look like in the case of uneducated deaf-mutes? We should be grateful if teachers for deaf-mutes could tell us something about this point.

We must also consider the general state of mind and temperament of deaf-mutes. In the literature on the subject we learn that the uneducated among them often appear queer and not easy to handle, but that the educated ones make quite a different impression. They are very often careful and vigilant, can concentrate well, and do good work in many trades. Their minds seem to be quite stable. Eichholz (1932) says: "During the period of childhood, given an early commencement of education, practically speaking, no problem of temperament arises." And later on: "They are happy enough in their own company." Their isolation from the hearing world does not prevent the deaf-mutes from entering successfully upon all the ordinary activities of life. They marry among themselves, and occasionally with hearing partners, found good homes, enter practically every industry for which hearing is not required, engage in sports, games, and generally lead the lives of normal persons.

This satisfactory picture does not, however, prevent the author from stating elsewhere in his report, that the deaf-mutes are often unable to adapt themselves to ordinary social life, and that conflicts arise in which they show awkwardness of temper, petulance, sometimes aggressiveness and violence, and that sometimes depressive states of mind, and even more severe forms of mental anomaly are found, with homicidal or suicidal tendencies, melancholy and insanity. He even mentions the very high proportion of insanity among the deaf-mutes, 1 : 42, while that among the hearing population is 1 : 295.

It is difficult to see why, in some cases, the absence of hearing power should not involve the individual's mental state at all, and in other cases lead to such serious consequences.

Probably such mental anomalies, where they appear, are not the consequence of the deafness, but of other factors. One of those might be the deaf-mute's technical difficulty in expressing himself. A second, more important factor, is that most of the deaf-mutes are, from the outset, not quite normal people, apart from their hearing defects. The congenitally deaf are degenerate individuals, showing abnormalities of their central nervous system, of their intelligence, and of their psychical disposition as well as some somatic stigmata. Where, however, deafness is not congenital, but acquired in early life, as for example after meningitis, we may also assume that the central nervous system has not survived the strain of the disease without lasting inferiority of function. Abnormal psychic conditions in all such cases would then appear not as consequences, but as co-ordinated factors in relation to the deafness.

Eichholz (1932) also states that he found 4% mental defectives among the deaf-mute children. These might very well account for the cases of insanity appearing in later life.

We see that even total deafness, in itself, does not necessarily impair mental well-being, and permits a reasonably satisfactory and happy mode of existence.

Why then do people who become deaf in later life so frequently show unhappiness, depression, or a state of intense suffering?

Fortunately there are many among them who, notwithstanding quite high degrees of deafness, still enjoy life and all it has to offer. Their case, like that of the deaf-mutes, indicates that deafness does not invariably lead to a depressive state of mind, and to mental suffering.

The deafened, as a rule, overestimate the extent of their deafness because of reasons physiological and psychological. Physiological reasons prevail in cases of unilateral or bilateral asymmetric deafness; here the weaker ear is often believed to be completely deaf. The explanation is that when a sound from one source reaches such a person, the weaker ear gets a weaker hearing impression. Under physiological conditions, this could only happen if the source of the sound were somewhere at the hearer's side. A normal person, when receiving an asymmetric hearing impression, would correctly localize the sound to the side of greater intensity. The same happens in cases of asymmetric defective hearing; there the hearing impression is always localized to the better ear; combined with the automatic and subconscious act of localization is the subjective feeling, that only that ear, to the side of which localization takes place, is functioning. And so the asymmetrically deaf are induced to believe that their weaker ear is not functioning, is completely excluded from the act of hearing.

There is a further cause for this overestimation of deafness. There are numerous occasions when even normal people do not hear what they are meant to hear. This may occur because, when speaking, many people articulate badly, or their voices do not resound well, or again because they cannot adapt the intensity of their voices to the prevailing acoustic conditions. The same may happen if there are disturbing noises in the neighbourhood, or if the person spoken to is preoccupied, or under nervous tension, or mentally fatigued.

A proof of the frequency with which inefficient hearing occurs among normal people is that all languages have their popular standard phrases inviting the speaker to repeat what he has just said. This fact cannot be explained otherwise than by the almost normal occurrence of faulty audibility of speech. Normal people do not mind such failures in hearing, but the deafened note these quite usual incidents and take them as a further proof of their defects, adding them to the "debit" account of their deafness, which is already sufficiently charged with their real deficiencies. Also the imperfections of telephones and similar apparatus are a continual source of disappointment to

the deafened, and add to their tendency to overrate their deafness just as does their habit of controlling their power of hearing by means of a watch, which, of course, gives quite a disproportionate impression.

If the deafened are, for reasons beyond their control, inclined to overestimate the extent of their deafness, many of them also overestimate the practical consequences of it.

We certainly must agree with them when they complain about considerable difficulties in their daily lives, and sometimes about severe hardships, but I still think that they take a far too pessimistic view of the situation.

We need not dwell too long on the difficulties in occupational life, which are doubtless quite considerable in many cases. On the other hand, we hear from Clark and Crowden (*v.* Bibliography) that many occupations can be, and are, filled successfully by the deaf, and we all have our own experiences, showing how people with very imperfect hearing are fully active in even important positions. But above all we find the same depressive state of mind, the same pessimistic outlook, in cases where no occupational or economic hardship is connected with the hearing defect. The main complaint, always repeated, is the "isolation", the difficulty or impossibility of enjoying company and social life and many relaxations and recreations. This point is stressed by both Nager (1928) and the Ewings (1938).

The intellectual life of our times depends much more on the optic sense than on the acoustic. Even amusement, entertainment, and relaxation have their own literature. Theatrical and musical performances are, to a measure, also accessible to the deafened. The "isolation" complained of concerns practically only the more trivial affairs of daily existence, such as the difficulty or impossibility of joining in the "small talk" of society and family, though artificial hearing aids and lip reading alleviate this trouble. The deafened are reluctant to admit their deafness and try to hide it. They will not ask for repetitions of sentences or words not sufficiently well understood, preferring rather to give a noncommittal answer. They are disinclined to use hearing aids and to study lip reading.

If the psychological reaction of the deafened to their defect seems to be out of proportion to what they really miss, could we find another reason to explain this exaggeration of their feelings?

After many years of observation I have a theory on this point. Every human being believes that he has a natural right and an inviolable claim to the integrity of his body and all its organs. An individual who finds out that this integrity has been lost, especially that one of the most important sense functions, his hearing, has suffered, experiences a severe psychic shock. He no longer considers himself as a "complete" person, and he believes that other people will not accept him as such any longer. He feels himself to be already excluded from the community of "normal" people. He becomes, in his own view, an "inferior" person.

A neurotic state then develops, a traumatic neurosis, produced by psychical trauma. True to the well-known clinical picture of the traumatic neurosis, the mind of the patient centres continually around the first shock.

There is a further point: many of our most depressed cases belong to the group of otosclerosis. This condition is understood anatomically, but not pathologically. Whether or not otosclerosis is endocrine in origin, these people represent a special type of a highly "nervous" character and highly unstable vasomotor conditions. It is quite possible that their preparedness for mental depression is to some extent due to their whole pathological condition and not just a normal reaction to their defects.

To the fact of the "psychic shock" we might attribute the exaggeration of the consequences of their defect; the never-ending complaints about their privations (loquacity of the neurotic) and many of the other mental peculiarities of the deafened.

Normal people may sometimes be somewhat reluctant in entering into conversation with the deafened or try to avoid their company because it seems a little troublesome, but they never look upon them as "incomplete people" in the way they do in the case of certain other afflictions or defects.

A good mirror of popular opinion is the literature of the stage and of fiction. Whereas the blind is always a pathetic figure, the deaf wherever he appears is almost invariably a comic figure. It is not a very high level of humour to make fun of a bodily defect,

whatever it may be, but the fact does show that deafness to the general public is not a serious defect like blindness. The reason is that deafness does not involve any "loss of personality".

There are many normal people who would be disinclined to enter into intimate—say erotic—relations with a crippled or disfigured person of the other sex, even when the defect is not very striking. But I do not think that anybody would be influenced in that way by the prospective partner's deafness. This again proves that no "loss of personality" is felt in the case of the deaf.

Returning to our main problem, the exaggerated character of the mental depression in the deaf, another support for this theory lies in the fact that quite a number of them, even after years of mental sufferings, are able to regain their mental and moral equilibrium. They have, to use the words of a deaf authoress, Margaret T. Monro (1934), "broken out of prison". They still have to bear all the difficulties and limitations which their defect imposes, but that does not prevent them from enjoying life in a reasonable manner, and with a modicum of happiness. Only the neurotic deaf believe that the hearing people are the entirely happy ones, and they themselves the eternally unhappy: a typically neurotic conception.

That the mental depression of the deafened is open to relief by the application of mental energy and effort seems to me to be the best proof of its neurotic character and origin. Only a few of the deaf can find their way out of their pathologically strained mental condition unaided. This opens a wide vista for psychic treatment and re-education.

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Dr. A. B. Stokes: The psychological association of any organic disability, considered from the point of view of psychosomatic medicine, immediately raises the point as to whether such associations are specific for the particular disability. If specific associations occurred, and they were abnormal in the sense of reflecting themselves to greater or lesser degree in disorders of conduct, they would certainly come within the purview of psychiatric practice; but in the clinical field it is found that whatever the organic disability may be, the psychological response, considered broadly, will take one of relatively few paths. Moreover, these general paths remain the same for all the organic disabilities and are not specific for any one of them. Thus one may get an anxiety response, or a depressive response, or a hysterical response, or a paranoid response, to the onset of blindness, but these same behaviour patterns are met with in patients who have lost a leg, or who know or have been told that they have a weak heart. Moreover, the pattern of reaction as it is seen in its association with the organic disability can be traced

back in time, so that before the disability became established, it can be usually recognized as a component of the personality operating less overtly when there is no hardship but becoming more florid in moments of stress.

The organic disabilities that I am considering particularly are those which do not affect the internal physiology of the body. Where there is a cerebral pathology or a biochemical change in the blood supplying the brain, the same thesis might be maintained, but would require the discussion of other points not pertinent here. The organic disabilities which *are* considered are therefore those which create social hardship and impose a burden on a personal adjustment to society. But such burdens arise in other ways besides that of physical defects—the death of a wife—the crash of a business—failure to achieve marriage. The psychological associations of these social stresses again conform to one or other of the same few kinds of general response, and the particular selection can be traced back to a component of the personality previous to the stress. Whether organic disabilities be compared with one another, or with other forms of social hardship, the possible forms of psychological reaction remain the same and each has its roots in the personality of the individual concerned.

A particular organic disability, however, considered as a stress, may pick out a certain kind of individual to whom it is a special hardship. The response of those individuals will then appear predominantly among the total possible responses. Thus the exuberant athletic individual whose leg is amputated will frequently react with a depression and among all such people this might appear to be the outstanding response—the hysterias and anxiety cases, &c., falling into the background.

Again on the broad background of a general response determined by the personality of the individual, details might be decided by the particular organic defect. Thus a blind man who, previously of suspicious kind, becomes paranoid in his blindness, might believe that people are looking at him sneeringly, or are putting obstructions in his path.

Applying the results of such a general survey to the particular instance of deafness one might say that the psychological associations are not, in their broad general patterns, likely to be specific; that the deafness and the social stress which it creates, act as the trigger mechanism for the release of behaviour responses grounded in the personality; that particular types of individuals may find the stress of deafness harder and their response is more likely to be pathological and predominant; and that within the broad patterns of reaction deafness may specify the details.

Among the deaf anxiety occurs which may be of such degree, that judged by social conduct, it is abnormal. It will be found in that type of person who from birth has been timid or apprehensive, and whose progress through life has been marked by periods in which anxiety has developed under conditions of strain. The previous situations have been resolved, but the present situation is inescapable in relation to the social milieu, and the anxiety response becomes florid. If the anxiety is associated with much visceral disturbance, and if the previous attitude of the person has been overconcerned with his bodily functions, then a florid hypochondriasis results.

A depressive state may arise in a person who in earlier life has shown that type of response to situational factors involving stress. In his depression he may show retardation of thought and action, may have self-depreciatory ideas, and be filled with gloom about his present, his past, and his future. More rarely, since it is a more rare general response, he may show a sense of well-being almost incongruous with his disability and be full of activity and drive, and be quite irrepressible in his social milieu. This response will occur in a person who has previously shown drive and possibly overactivity in relation to his difficulties.

A schizoid response may be obtained in a person who has always seemed retiring, shy, unable to make contacts, who withdraws into a shell at the least criticism or hardship and who has always been regarded as sensitive.

Similarly, according to the individual, hysterical, obsessional, or paranoid responses may develop. Yet with all these possible abnormal responses the number of deaf people in a psychiatric clinic is not greater than would be accounted for by their distribution among the general population. It is those persons of susceptible personality make-up who break down under the strain of deafness.

Hardness of hearing and the social situation which it creates, represents a great burden, but particularly so to those individuals who, before their deafness, lacked strength in

themselves, responded to their environment by inferiority reactions either conscious or unconscious, and bolstered their own inadequacy with the help of others. Such persons deriving their support more from the outside than within themselves, fall down under an oncoming deafness, and show frequently an anxiety, with petulant anger or timorous withdrawal, combined oftentimes with hysterical features which may later dominate the picture.

A specific colouring given to a general trend is shown among the deaf where a paranoid reaction develops, i.e. where behaviour is decided by the belief that society is hostile. Hardness of hearing impedes social converse and sets the patient apart from society. He observes society out of self-interest, and is very apt to refer actions which he cannot comprehend as implicating himself, that is to think that the conversations of others may be about himself. This phenomenon is almost universal among the deaf, and is equivalent to the feeling engendered in a lone stranger living in a foreign land, the language of which he does not understand. But some, of all deaf people, have a paranoid set to their personality, and in their case this general self-reference is carried further with the development of a fixed belief in hostile conversation, that society is exposing their weaknesses, their faults, their sins, their crimes, shouting them abroad. The patient can hear these traducings, but not the word of the doctor to whom he is speaking. It is this striking contrast which has given rise to the belief that deaf people are particularly prone to paranoid reactions, but I doubt whether deafness is more common among all paranoid patients than it is among the general population. The personality factor is the fundamental one.

What is meant by personality? At conception specific endowments are given to the individual, the development of which is dependent on the genetic milieu and on the experiences to which the individual is subject. The experiences of early life more or less fix the trends of development and establish the possibilities of compensation. The integration of all such trends, physical and psychological, constitutes the personality. In detail it is individualistic, but in broad survey it conforms to one of few patterns.

Various schools of psychopathology view the personality make-up and the processes which enter into its formation differently, but for my purpose it is sufficient that all agree to the principle of broad general trends of development with individual detailed differences. They stand or fall by the validity of their premises and the truth of their theories. Since the same material is the basis of their work, ultimate co-ordination should be possible, and any work which furthers the study of the personality, including the factor of genetic constitution, is of tremendous importance in the problems of psychosomatic medicine.

When the personality has to adjust to the onset of a stress such as deafness, the effect of the speed of onset requires some consideration. In a very general way more acute situations precipitate, in predisposed individuals, an affective response (usually either depression or anxiety) or a hysterical state, whereas a slowly developing deafness enlarges the possibilities of compensation, but may bring out in predisposed individuals a paranoid response. The deafness may be produced in a situation so acute that elements in the situation, other than deafness, may be the deciding factor in the response. The importance of this consideration lies in the fact that where the response is hysterical the minimum of deafness may be augmented functionally, or a transitory deafness may be perpetuated by the functional mechanism. This is well known to occur following the blast of an explosion, but it occurs in people whose personality make-up favours the hysterical reaction.

The occurrence of deafness in children presents special problems, from which, in accordance with the point of view I am developing, I must select the effect on personality maturation. Trends of conduct are impeded in their social organization while at the same time social stress is increased. Behaviour problems, therefore, arise, but the particular ones, which come to the doctor because they are most obvious or most disconcerting to the parents, are the aggressive uncontrollable reaction or the apparently stupid withdrawn child. The particular form which the reactions take may again be referred to the kind of child in whom the deafness arises, and is no different from that which occurs in predisposed children subject to stress of other kinds.

The lessening of the burden of deafness by the use of hearing-aids, by lip reading, and by social readjustments, will allow compensations to develop within the personality. An understanding of the kind of person to be dealt with, will indicate how the best compensations may be fostered.

Mrs. I. R. Ewing, *Department of Education of the Deaf, Manchester University* : The psychological effects of deafness depend upon many other active and reactive factors in addition to deafness itself—the health and age of a patient; his environment and experience; his social attitude, and his disposition towards difficulties; his intelligence, and physical and mental readiness or unreadiness to acquire new habits; the nature of his work and interests, his resourcefulness and his sense of humour.

There are special psychological problems arising from deafness which can be simplified, or solved, by taking into account the information afforded by the otologist's diagnosis together with the results of certain tests. These comprise pure tone tests of hearing both by air and bone conduction, and tests of hearing for speech with the aided and the unaided ear. Mental and social life is very largely conditioned by capacity to communicate freely with others. To judge how far normal mental life is possible for a patient who suffers from chronic deafness we need to know how far he can be enabled by the combined means of lip reading and hearing to follow the spoken word in all the circumstances of his daily life. The second thing we need to know about him is whether or not he is likely to continue to speak intelligibly and audibly or whether his speech will deteriorate in the course of time unless remedial measures are taken.

The results of tests of hearing help greatly in assessing a patient's potentialities for free communication.

It is proposed to analyse the case-histories of several adult and adolescent patients. Two of these patients suffer from middle-ear and one from internal-ear deafness. The psychological effects of deafness upon each of these three patients is analysed under four heads :

(*a*) Capacity to follow what is said by other people.
(*b*) Ability to continue to talk intelligibly and audibly.
(*c*) Thinking.
(*d*) Employability.

Patients whose deafness is sometimes described as mixed are not considered as a separate group because no additional special psychological problems arise in their case. In so far as both middle and internal ear trouble are present their mental and social life is conditioned by the particular psychological factors which are related to each of these forms of deafness.

Analysis.—In circumstances which are favourable for both hearing and lip reading X can follow the speech of other people with 95% accuracy in each of the three conditions which prevail in daily life, viz. *tête-à-tête* conversation, group conversation, and speech at a distance of from 25 to 30 feet in an auditorium.

Thus we can state that this patient suffering from middle-ear deafness, according to his intelligence and the extent to which he puts into practice the advice given to him about ways of alleviation, can keep pace in following the quick flight of the conversational ball as it is tossed to and fro. He can, if he will, contribute an active although limited part in social intercourse. He is also in a position to enjoy and to share the mental stimulation which comes from mass listening.

He can get this form of general mental stimulation only if he is prepared to exert his mind more than would be required if he could listen normally. 95% represents his highest score in following spoken words under test conditions. There are many times when the poor acoustic properties in a room or hall, poor lighting, indistinct speech and bodily movements of a speaker who directs his words and turns his face to right and left, hamper the patient's hearing and lip reading. Some of the words he misses are not vital to the sentence, others are key words to the thoughts being expressed. There is often therefore an element of doubt at the back of X's mind as to what has been said. From personal experience and from information supplied by many deaf patients the writer ventures to state that thinking is hindered by that constantly recurring element of doubt ; it is slowed up temporarily as are the steps of a man who walks suddenly into a mist.

Contribution to thought in conversation or discussion is constantly being inhibited because of that doubt. Either mental hesitancy or else a kind of self-defiant aggressiveness is in danger of becoming habitual. Range of thought and interest are not seriously narrowed in the case of X. There are certain activities closed to him. For example he

could not serve wholly efficiently as the chairman of a big committee, or become a fire-watcher who co-operates with others in the dark, but there are countless other ways of service open to him. There is no need for him to develop a sense of inferiority.

His audiogram shows that his hearing by bone conduction is less impaired than his hearing by air conduction. X is able to hear his own speech by bone conduction. He continues therefore to speak intelligibly. He needs to guard against one pitfall. In noisy places when other people raise their voices to be heard X will fail to accommodate his voice to the loudness required by normal listeners. To him external masking noises are inaudible or appear as if reduced in volume, and, hearing his own voice above them, he believes he is talking very loudly and so he lowers his voice.

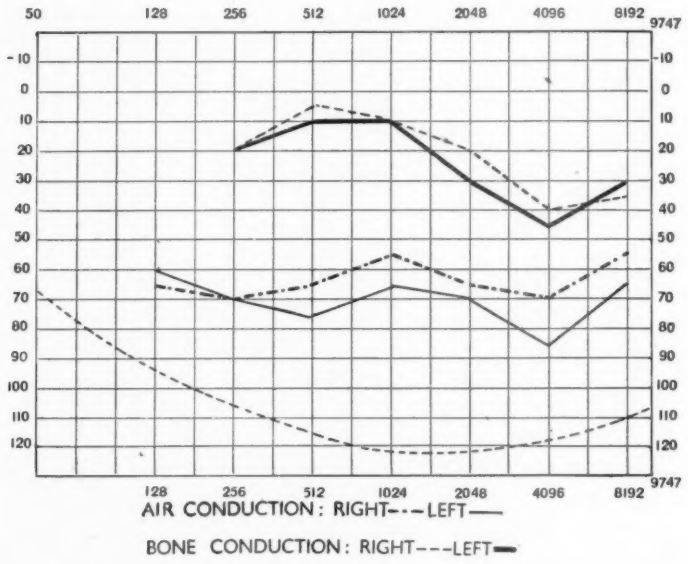

FIG. 1.—Patient X, aged 54. Age at onset of deafness 30 years. Diagnosis: Otosclerosis. No history of deafness in family. Speech tests—Consonant score: Unaided hearing at 3 feet, 10%; aided hearing (with valve aid), 63%; lip reading, 40%; hearing (valve aid) combined with lip reading, 87%; hearing (valve aid) combined with lip reading in words and sentences, 95%.

Unless he guards against this defect he will gradually become aware that conversation in a crowded or noisy place is not easy and enjoyable. The writer knows a number of deaf patients who have gradually withdrawn from large gatherings for this reason. They have attributed to their deafness the mental discomfort involved in conversation. Actually it has been due to the ineffective accommodation of their own voices to the needs of normal listeners.

The position of X is favourable with regard to employability unless the nature of his work is such that he cannot use a hearing-aid. Then he must depend entirely upon unaided hearing and lip reading. Fear will certainly come into the picture then, fear lest his deafness will progress, fear that orders may be given to him or questions asked when he is not looking, or from a distance. The dread of unemployment will begin to haunt his mind, a factor which may influence adversely his attitude towards his work and which may also diminish his efficiency.

The degree of deafness from which X suffers is severe but it has mitigating characteristics through which he can attain a valuable measure of compensation. Such compensation lessens the isolating effects of deafness and enables X, if he will persevere, to live a relatively full and happy mental life.

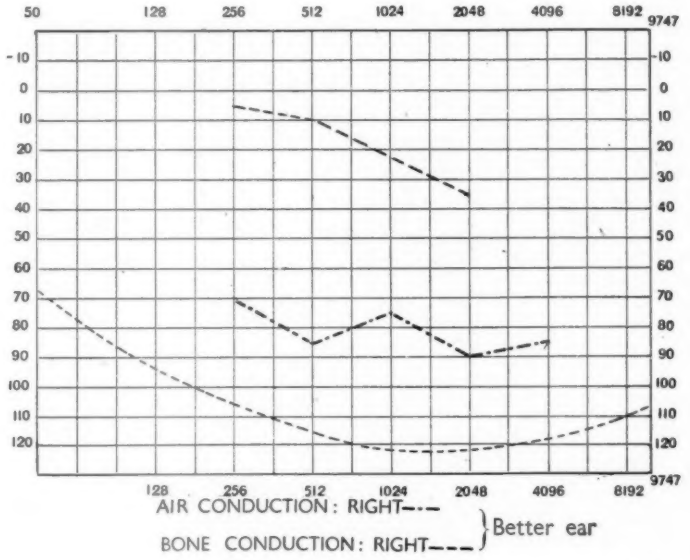

FIG. 2.—Patient Y, aged 18. Deafness both sides. Gradual onset for ten years. Tonsils and adenoids removed eight years ago. Paracentesis right ear eight years ago. Influenza eight years ago; deafness appears to follow this. No history of measles or scarlet fever. No changes indicated in drums. No gross disease in nose or nasal pharynx. Both Eustachian tubes patent. Weber's test not lateralized. Rinne's test negative both sides. Bone conduction diminished both sides. Speech tests (right ear only)—Consonant score: Unaided hearing at 3 feet, nil; aided hearing (valve aid), 90%.

Analysis.—The psychological difficulties which face Y are of the same nature as those which face X but the necessary process of adjustment began at the early age of 10. The years from 10 to 18 are critical in the development of a boy's mental, moral and social life; the framework of his future is being outlined. His educational achievement at every stage is largely dependent upon his ability to follow the spoken word. Every time there is failure to understand speech his thinking is hindered and his education is retarded. X had enjoyed a long period of normal mental life before being faced with the effects of deafness. Y has lived under normal conditions during the most formative years of life, but he has no great store of knowledge; his interest and abilities are not yet fully determined. At the age of 16 examination showed lack of background in all elementary subjects. The mischief had begun early; it escaped detection for a few years; at school Y was considered a dull boy.

Speech training and intensive education through lip reading and with the help of a hearing-aid resulted in this patient being able to follow a business career with great success. He enjoys a relatively normal mental life and has the satisfaction of knowing that he is capable of economic independence.

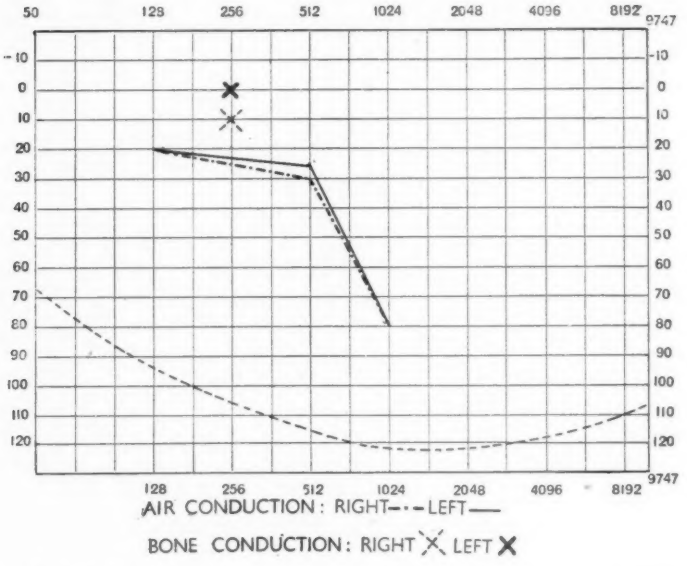

FIG. 3.—Patient Z, aged 20. Delicate baby (weighed 3½ lb. at birth). Heart trouble. Age of onset of deafness unknown. When first seen at age of 16 years was an unsatisfactory pupil at a normal school although of more than average ability. Speech was mumbled and almost unintelligible and vocabulary was subnormal. There was great unwillingness to talk to strangers. Speech tests (right ear only)—Consonant score: Unaided hearing at 3 feet, 40%; aided hearing (valve aid), 70%.

Analysis.—In Z's case loss of hearing for the upper part of the speech range seriously reduces the intelligibility of speech while the less severe loss at the lower end of the scale only slightly reduces the loudness of a speaker's voice. Thus distortion is a permanent characteristic of the speech which Z hears. The presence of noise, the hum of voices and the hubbub caused by movements all appear in distorted form to him. In the presence of such noise which masks so many of the consonants, *tête-à-tête* or group conversation becomes totally unintelligible to Z, and the distortion of speech is still worse if he listens through a hearing-aid. In these circumstances he must depend entirely upon lip reading.

It is clear that both the mental and social life of Z will be greatly restricted. He can only enjoy conversation with others when the environment is quiet. He always has great difficulty in following group conversation. In an auditorium he can hear the rise and fall of the voice throughout a play or a lecture, but he cannot distinguish the words being spoken. Loss of hearing by bone conduction is also severe, therefore he will not be able to hear his own speech normally. He may raise his voice to make it audible to himself or he may begin to reproduce speech as he hears it, quietly and indistinctly. It is probable that his speech will deteriorate rapidly unless he takes remedial precautions.

The word patterns he hears and sees are imperfect and often blurred. Does he retain clear word images in his thinking or in the course of time do the speed and clarity of his thinking suffer too? His inability to converse freely with other people limits also the range of his interests and sympathies, his understanding of other people and their motives for action. He is debarred from many forms of activity which depend upon co-operation with others. Co-operation is always difficult for Z because the presence of other people means noise and noise is the enemy of a patient suffering from partial deafness due to internal-ear trouble. Choice of career is obviously limited for Z. He

hopes to enter a University next term to read for a science degree. Apart from his natural aptitude and personal suitability for the career he has chosen, his chance of making a success of it depends upon his ability to lip-read and to retain normal speech. The threat to the mental life of a patient suffering from severe internal-ear deafness is always very serious. It becomes even more serious and complicated when the deafness is total.

Two patients have recently visited our clinic. Both became totally deaf as the result of cerebrospinal meningitis. A was 32 years old, a cotton operative. He was told by his employer that if he could learn to lip read within three months he could keep his post. If not, he must leave. He fulfilled the condition and he kept his post. The effect upon him of the situation arising through deafness was that of a mental stimulant. The threat of social isolation and unemployment acted as a drive which summoned to his aid all his remaining powers.

B was 20 years old, he was at a University and was reading law. He suffered badly from shock and severe depression which took suicidal form. At first it was difficult to rouse his interest in anything. Intercourse by writing was too impersonal and slow to prove helpful in ways which would have met his mental and emotional needs at that time. He brooded over his troubles and resented any offer of help. At first he took no interest and appeared to have no faith in lip reading. It was hard to induce him to make the necessary concentrated effort which lip reading requires. Very gradually as he made progress his attitude towards people and his particular difficulties changed. He is learning to adjust his mind and adapt his behaviour to the hard new conditions which total deafness imposes.

When deafness occurs in childhood the complexity of the psychological problems involved are intensified. Intelligence, knowledge, mental habits, social attitude and business efficiency are already determined in the adult, whereas they are developing in the child. Normally the development of these factors in mental life depends very largely upon the capacity to speak and to understand the spoken word. Mental development and speech development are largely interdependent. Even a slight degree of deafness at any age during childhood retards both the comprehension and the acquisition of speech and knowledge. Severe or total deafness in childhood prohibits normal development of speech. Still more menacing to the mental life of the child is the way in which he must think without words, conform to a code of behaviour without reasons or explanations, follow activities without clear directions, mix with other children without being able to play freely with them, live the life of a child in circumstances suitable only for a recluse.

It is obvious that on account of his deafness a child's mental development is seriously retarded; his emotional experience is intensified but limited; his sympathies and interests are confined to persons and objects he can see ; he feels the urge to give expression to his emotions and thoughts, and experiences repression when he can find no satisfying outlet for them.

He often meets with fear and dread and mental conflict. The writer on more than one occasion has found great difficulty in pacifying and calming a young uneducated deaf child who has experienced terror in a dream. Mainly through touch can his sense of security be restored. The comfort of words and the sound of a familiar voice are denied him.

In a number of young deaf children, aged from one to two years, the writer has observed backwardness in walking although in play other movements appear to be normal. One such patient is at present brought to the Manchester clinic every week for the writer to observe her response to certain forms of training. Ann is now 18 months old. Training began three months ago. So far there is no evidence that she can respond to sound of any pitch or loudness. The object of the training is to preserve the natural quality of the child's voice, through babbling, and to lead her to watch the face of a speaker as naturally as a child with normal hearing pays attention to the sound of a voice.

Ann cannot yet walk alone and has great difficulty in balancing herself. The late Dr. Phyllis Kerridge very ably illustrated in a film the defects of balance from which congenitally deaf children often suffer. The writer suggests that there is also another factor which is responsible for the delay in Ann's walking. She can balance herself well enough to stand if her hand or even a finger rests on a chair. She can walk a few steps if she propels herself along with the help of a chair but when she does this her eyes are riveted on it. She cannot take her attention from the chair to look at her mother's face. Under the same conditions a child who could hear would be spurred on to persistent

effort by the sound of her mother's voice and by her words of encouragement. Ann misses this kind of incentive to progress and her interest in walking and the chair quickly fails.

The writer gives this single illustration of delay in thinking and performance from hundreds of similar instances which she has observed and noted. Their sum total accounts for the degree of mental retardation which gradually accumulates throughout the pre-school years because in those years speech has played no part in the mental life of the deaf child.

Grateful acknowledgments are made to the Trustees of the late Lord Leverhulme, the Medical Research Council, and the Pilgrim Trust, for financial help towards the cost of the investigation.

Clinical Section

President—G. DE BEC TURTLE, M.D.

[*February* 14, 1941]

MEETING HELD AT THE WESTMINSTER HOSPITAL, S.W.1

THREE CASES BY SIR ADOLPHE ABRAHAMS, O.B.E. M.D., F.R.C.P.

I.— Generalized Osteoporosis, Thyrotoxicosis and Fits.

Female, aged 55.

First seen in April 1940 with a history of goitre for twelve years. She has been more irritable of recent years, prefers cold weather, and sweats easily. One year: dyspnœa on exertion, getting worse. Legs have become bent and back bowed. Five months: attacks about once a month of difficulty in articulation for some ten minutes, with faintness. In third attack, also twitching of right cheek, right side of neck and jerky movements right arm; consciousness lost for two hours. Numbness and coldness of right hand. Two months ago: similar attack with unconsciousness; several minor attacks since. Now has persistent dysarthria and aphasia of motor type. Recent deafness right ear. No headaches or vomiting.

Past history.—When aged 16, bilateral ovariectomy by Mr. Bland-Sutton for ovarian cysts.

Family history.—Mother died aged 78, suffered from attacks of speech defect. Father died aged 43, from tuberculosis of the lung.

On examination.—A small woman with large vault of skull. Brownish papules on face and brownish diffuse pigmentation all over body. Long bones deformed. Full movement of joints. Nodular goitre quite obvious. No tremor or eye signs. Tachycardia 110. Apex beat slightly out. Loud late systolic murmur (high pitched). Blood-pressure 130/80. Chest and abdomen clear. Hypogastric scar. Central nervous system: Slurred speech. Fundi clear Fields full. Pupils active, equal. Cranial nerves normal. All tendon-jerks present and equal. Abdominal reflexes present. Plantar reflexes flexor. No sensory loss.

Description of fits.—Foul taste in mouth, then blurred vision right eye and twitching, 2 per second, of right face and neck with increasing dysarthria. Mentally distressed but not unconscious. Restless but no movement of arms. Sudden cessation of twitching after two minutes and improvement in speech within a few minutes, leaving residual slurring.

Investigations.—X-rays show—Skull: increased thickness but density normal; left femur and tibia: rarefied, not thickened. Cerebrospinal fluid: Pressure 175 mm. Hg. No cells. Protein 0·05%. Pandy's test faintly positive. Nonne-Apelt reaction negative. Wassermann reaction negative. Blood phosphatase: 21 (normal 3 - 13). Blood-calcium: 12·7 (normal 9 - 11).

Electrocardiogram (15.4.40): Normal rhythm 90. Q.R.S. slurred.

Basal metabolic rate (16.4.40): +50%; (10.5.40): after fifteen days iodine, +31% (pulse fell ten per minute).

Skiagram of chest: No retrosternal shadow. Scoliosis and some collapse of two dorsal bodies.

During recent months the fits have recurred in spite of luminal gr. ½ t.d.s. The fits are attributed to pressure from bony changes in the skull. Her appearance is that of Paget's disease and the skull has probably enlarged.

II.— Hanot's Unilobular Cirrhosis of Liver. Chronic Jaundice. Pigmentation of Skin.

Female, aged 48, unmarried.

In 1932 the patient first became jaundiced and since then the condition has persisted on and off. Infections appear to deepen the jaundice. Skin irritation has been troublesome for the past two years, but began several years before. Six years ago nausea and vomiting with abdominal pain diagnosed as gastric ulcer. Nails brittle, deformed and did not require cutting. In 1937, while an in-patient, there was no jaundice but brown pigmentation on the abdomen, and the liver and spleen were slightly enlarged.

Investigations (performed in 1937): Blood-count: R.B.C. 4,010,000 ; Hb. 72% ; C.I. 0·9 ; W.B.C. 5,800. Polys. 64%, lymphos. 33%, monos. 3%. Mean diameter of red cells 7·6 μ. Van den Bergh : Delayed direct reaction slightly positive. Indirect reaction 0·9 mgm.% bilirubin—later 1 mgm.%. Fragility: Hæmolysis begins 0·4% saline and is complete 0·25% saline.

Erythrocyte sedimentation rate: 38 mm. at end of one hour.

Wassermann reaction and Kahn test negative.

Galactose tolerance test: Total excretion in five hours—1·4 grm.

The patient has been abstemious and has not been abroad. Menopause occurred in 1936. There is no history of jaundice in the family, though one brother is said to have a particularly sallow complexion.

On examination.—Small woman with moderately severe jaundice and diffuse uniform brown pigmentation of the skin, but not of mucous membranes. Nails atrophic and thickened. Liver greatly enlarged, reaching right iliac fossa, firm, smooth and not tender. Notch in anterior border. Spleen enlarged one hand's breadth below costal margin. No ascites. Diminished breath sounds at both lung bases due to high diaphragm. Blood-pressure 112/70.

Investigations (March-April 1940).—Urine : Urobilin+ ; Ehrlich's test+.

Blood-count: R.B.C. 4,960,000; Hb. 82%; C.I. 0·8; W.B.C. 6,000. Polys 70%, lymphos. 23%, monos. 7%. Mean diameter of red cells 7·6 μ. Reticulocytes less than 1%. R.B.C. and platelets appear normal.

Mean corpuscular volume 78 c.μ (normal 80 - 94). Mean corpuscular Hb. 22·6 $\gamma\gamma$ (normal 27 - 32). C.I. 0·79$\pm$0·03. Volume index 0·87$\pm$0·03. Saturation index 0·85 $\pm$0·04.

Fragility (fractional): Hæmolysis complete at 0·4% and begins 0·55% (normal 0·5 - 0·4).

Van den Bergh: Direct, biphasic ; Indirect, 16 mgm. bilirubin %.

Glucose tolerance test normal.

Skin section: Melanin. No hæmosiderin.

Serum cholesterol: 193 mgm.%.

Galactose tolerance test: Grossly abnormal. Index 352 (max. normal 160).

This case is characterized by chronic jaundice, enlarged cirrhotic liver and absence of ascites. The pigmentation of the skin and atrophic nails are special features.

Discussion.—Dr. F. PARKES WEBER agreed with the diagnosis, he regarded the case as one of *chronic biliary cirrhosis of Hanot's type*, in which the cirrhotic process obstructed the minute biliary ducts rather than the portal blood-vessels. But at the present advanced stage of the disease he would expect the histological picture to show no longer a purely unilobular distribution of the process. A melanin deposition in the skin probably accompanied all very chronic jaundice.

The hepatic changes in chronic progressive jaundice—including the very rare Hanot type—could probably be explained by recurrent necrosis of hepatic glandular cells associated more or less with compensatory hypertrophy of remaining parenchymatous cells and replacement or irritative fibrosis. When, in spite of compensatory processes, too little parenchymatous tissue remained, death ensued. An in-born tendency doubtless had something to do with the incidence of the disease.

Dr. BRUCE PEARSON was of the opinion that a provisional diagnosis of recurrent subacute yellow atrophy should be considered. This occurred from time to time without any obvious known ætiological factor of a toxic nature such as arsenic.

III.—Spina Bifida, Half Vertebræ, Syringomyelia and Albinism.

Male, aged 21, boot repairer.

History.—In early 1940 the patient noticed that he frequently injured his left hand without pain while at work and he burned his fingers with cigarettes, equally painlessly.

Defective vision has been present since birth. In 1929 he had "kidney trouble" and "dropsy" but remembers no details. In 1933 he was alleged to suffer from rheumatic carditis.

Family history.—Father died of perforated ulcer. Mother well. An only sister, aged 29, is almost blind.

On examination.—A fairly well-developed individual with greyish hair. The iris shows very little pigment on either side and there are severe myopic changes in the fundi. Coarse nystagmus. Cranial nerves otherwise normal. Upper limbs show numerous scars due to cuts and burns. No motor changes in upper or lower limbs. *No wasting.* All reflexes normal. Pain and temperature sensations are impaired in both upper limbs but the face is spared. In the lower limbs vibration and postural senses are diminished. Heart and lungs normal. Blood-pressure 130/80. Urine normal. Skiagrams.—Spine: Spina bifida and half vertebræ in dorsal region. Kidneys: Normal.

Adamantinoma of the Lower Jaw.—E. S. Lee, M.S., F.R.C.S.

J. T., male, now aged 51.

In 1926, at the age of 36, after some teeth had been removed, he noticed a small swelling on the outer aspect of the right side of the lower jaw. It grew rapidly larger, and a year or so later a local curettage was performed at a local hospital. The swelling soon reappeared, and in 1929, when he first came to Westminster Hospital, there was an elastic tumour in the substance of the body of the jaw. A blood-stained discharge entered the mouth by a small opening on the inner aspect of the mass. Local excisions were performed in 1929, 1932, 1934, 1935, and again in 1936. On the last occasion, operation was

Fig. 1.—Showing tumour of jaw on 18.9.31.

Fig. 2.—Showing latest recurrence in cut end of mandible, 11.2.41.

supplemented by the application to the outside of the jaw of a plaque carrying 60 mgm. of radium at a skin distance of 4 cm. By this means a dose of 12,000 mgm. hr. was given. Later, one course of deep X-ray therapy, amounting to 1,920 r units to the skin, was tried.

The skiagrams during these years show a steady extension till eventually the entire right side of the mandible is involved (fig. 1). A cystic, trabeculated appearance is seen, becoming more and more attenuated until the bone disappears completely. The histological sections are particularly interesting, as they reveal a gradual transition from a "typical

glandular adamantinoma" (1929), to a "continuous sheet of spindle cells, suggestive of malignancy" (1936).

In 1937 a resection of the whole of the right half of the mandible, including the condyle, was performed by Mr. G. T. Mullally, and the patient then remained well until the latter part of 1940, when a tumour appeared in the soft tissues near the scar, and the bony stump in the region of the symphysis menti began to enlarge. Fig. 2 shows present condition.

TWO CASES BY S. P. MEADOWS, M.D., M.R.C.P.

I.—Intracranial Aneurysm. Cephalic Bruit and 3rd Cranial Nerve Palsy.

E. H., female, aged 41.

History.—Gradual onset of left ptosis eighteen months ago, associated with pain in the left eye. Eight months ago, numbness of left infra-orbital region noticed.

On examination.—Complete left 3rd cranial nerve palsy, with consequent ptosis, fixed but not dilated pupil, and abducted eye. 4th and 6th cranial nerves intact. Slight cutaneous sensory impairment over left infra-orbital region, but corneal reflex intact. Slight left exophthalmos. Systolic bruit audible over left eye, which disappears on compression of left common carotid artery.

X-rays of skull and of sphenoidal fissures normal.

Cerebrospinal fluid of normal pressure and composition.

Wassermann reaction negative in blood and cerebrospinal fluid.

II.—Calcified Craniopharyngioma.

E. C., male, aged 35.

History.—Progressive loss of vision over about twelve years, but only severe loss during few months prior to operation. Only occasional headache. Has never needed to shave. Teased at school about feminine appearance. No thirst, polyuria, or hypersomnia. Able to work as labourer.

On examination (February 1939).—Small frame, and of feminine appearance. Facies a mixture of youth, age, and femininity. Smooth, hairless face. Hairless trunk and axillæ. Scalp hair silky. Pubic hair scanty. Infantile genitalia. Voice high pitched. Optic fundi: bilateral primary optic atrophy. Visual fields: bitemporal hemianopia, the defect spreading into the lower nasal field on the right side.

Visual acuity: R. $\frac{6}{24}$; L. $\frac{6}{6}$.

Blood-pressure 125/80.

X-ray of skull: Sella completely destroyed. Enormous calcified mass above sella.

Glucose tolerance test: Flat type of curve, highest blood-sugar 0·12%.

Operation (3.4.39), by Mr. G. H. Macnab.—Left frontal approach. Large thick-walled calcified cyst in suprasellar region. Aspiration of brownish fluid. Part of cyst wall removed. Pressure on optic nerves relieved. Normal post-operative convalescence.

Microscopy: Fibrous tissue, with areas of epithelial tissue and of calcification.

Returned to work on farm.

Lindau's Disease.—G. H. MACNAB, F.R.C.S.

D. F., female, aged 19.

May 1939: Admitted to hospital complaining of attacks of severe generalized headache associated with vomiting, which occurred early each morning; some diplopia at the onset of the attacks of headache. These symptoms had been present for nine weeks and were increasing in severity. She had not complained of giddiness.

For the past two years she had been under the care of Mr. J. G. Milner, who observed the condition of her right eye from time to time. He stated that on first examination there were two sets of greatly enlarged retinal vessels which appeared to arise from the disc and run temporalwards. The vessels increased in size and gradually detachment of the retina took place. The original picture became gradually obscured.

The patient was referred to Dr. S. P. Meadows at the onset of the symptoms of headache and vomiting.

On examination.—The patient was drowsy and complained of severe headache. Speech and mentality normal. Left fundus: early papillœdema. Right fundus: detached retina. Ocular movements full. No evidence of nystagmus. Other cranial nerves normal. No

localizing signs on examination of motor and sensory systems apart from slight neck rigidity. Cerebrospinal fluid: Pressure 300 mm. Hg. Clear and colourless. Cells: none seen. Total protein: 0·01%. Globulin, Nonne-Apelt: Negative. Pandy's test negative. Wassermann reaction negative.

In view of the history of angioma of the right retina it was suggested that the patient was suffering from a cerebellar hæmangioblastoma. As there were no definite signs present on clinical examination ventriculography was carried out. The ventriculogram showed a generalized hydrocephalus with displacement of the aqueduct of Sylvius and 4th ventricle to the right.

Operation.—The posterior fossa was explored. The left cerebellar lobe was enlarged and distended and had a yellow appearance. The lobe was incised and a large cyst containing yellow fluid was exposed. The wall of the cyst was smooth, but a small mural nodule, the size of a pea, was found protruding into the cavity. This nodule consisted of a mass of angiomatous vessels. The lining of the cyst and the mural nodule were excised and the patient made an uninterrupted recovery. A section of the mural nodule showed it to be a hæmangioblastoma.

Since then the patient has complained of no symptoms. She has resumed her studies and will shortly qualify for her degree at a technical college.

Two Cases by D. N. Matthews, M.D., F.R.C.S.

I.—Penetrating Bayonet Wounds.

F. P., aged 24, a soldier, was sent to hospital with the history that he had fallen on his bayonet whilst at practice. The bayonet had been removed from the left ischio-rectal fossa where it had entered and a stitch had been put in the skin as the bleeding had been profuse. There was a small exit wound in the left subcostal region.

He was very shocked and the abdomen was rigid. On catheterization only a little blood-stained fluid was recovered. He was given a pint of citrated plasma and this was followed by a drip transfusion which was running during the operation. A laparotomy was performed; the spleen and left kidney were examined and found to be uninjured, but there was a small hole leading from the peritoneal cavity into the base of the bladder. The bladder was therefore opened and an attempt was made to suture it, after which both the bladder and the peritoneal cavity were closed with drainage. The wound in the buttock was sprayed with sulphanilamide powder and drained, as was also the wound in the side.

At first all the urine was passed through the intraperitoneal tube and an intravenous pyelogram was therefore obtained. This showed that the left ureter was intact, but that urine was escaping from the left side of the bladder wall. After the insertion of a urethral catheter the intraperitoneal drainage diminished and the suprapubic wound closed.

Two weeks later, an abscess developed at the base of the bladder which could be felt *per rectum*, and the drainage through the urethral catheter diminished. The bladder was therefore reopened when the abscess discharged into the bladder, and a suprapubic tube was left in situ. Later the urethral catheter was replaced and the suprapubic tube removed.

Three weeks later the temperature began to swing and rigors followed. He was seen to have some discharge around the urethral catheter which was therefore removed. The fever immediately subsided and convalescence was afterwards uneventful.

II.—Carcinoma of the Thyroid.

M. E., female, aged 20.

History.—A swelling had been noticed in the region of the thyroid since the age of 5, and some iodine had been given from time to time by her private doctor. At the age of 11 she weighed nearly 12 st. and was described as "rather slow". Periods began at the age of 12 and were regular but scanty. She now appears normal for her age and has lost her obesity; she is intelligent and no longer lethargic.

Treatment.—First seen at Westminster Hospital aged 16, when in addition to nodular enlargement of both lobes and the isthmus of the thyroid she had bilateral discrete masses thought to be glands. Diagnostic puncture revealed only thyroid tissue in which there was no evidence of malignancy nor was there any evidence that the mass was a gland. Partial thyroidectomy was then performed and the gland was found to be adherent to the trachea and infrahyoid muscles.

Pathological report.—Two sections were cut: (1) Adenoma of the foetal type; (2)

grossly atypical thyroid tissue ; in places calcified and markedly papilliferous. This portion is histologically in the class of "malignant adenoma of Vaux ".

The patient had radiotherapy with the 4 grm. bomb, the 2 grm. bomb and deep X-rays, and later in the same year was readmitted for removal of the ectopic thyroid masses.

The pathological report was to the effect that the thyroid was atypical with papilliferous high columnar cells. The section was submitted to Dr. Vaux who stated " it appears to be a malignant adenoma with a papilliferous structure in some parts ".

The removal was not complete owing to fixation and severe hæmorrhage. The neck was again irradiated and the remaining glands showed marked regression. She had three courses of treatment with the 4 grm. bomb, one with the 2 grm. bomb and three with deep X-rays over a period of twenty months, after which she has remained well for thirty months. There is no sign of recurrence.

After the radiotherapy she had considerable scarring and telangiectases of the neck, for which double abdominal tubed pedicles have been brought to the neck by way of the wrist to repair the cosmetic deformity.

Dr. D. M. VAUX had seen the patient four years previously when the first operation for partial thyroidectomy was performed and had examined the section of the goitre shown at the meeting. It was a malignant adenoma of the thyroid showing the histological criterion of malignancy first pointed out by Graham, viz. an intimate relationship between the tumour cells and thin-walled blood-vessels. In some parts of the tumour there was a papilliferous arrangement such as was seen in the adenocarcinomatous variety of malignant new growths of the thyroid. Dr. Vaux thought that this might be correlated with the early infiltration of surrounding tissues which the case showed, since extension through its capsule was usually a later occurrence in a malignant adenoma of the thyroid.

Section of Laryngology

President—T. B. Layton, D.S.O., M.S.

[*March* 7, 1941]

Chronic Hyperplasia or Focal Osteitis Fibrosa of the Maxilla

By E. D. D. Davis

Focal osteitis fibrosa of the maxilla is well illustrated by fig. 1. This condition has recently been labelled focal osteitis fibrosa or localized osteitis fibrosa (E. Godfrey Collins, 1939), osteitis fibrosa circumscripta (Colyer and Sprawson's "Dental Surgery").

Westmacott (1913), at the International Congress of Medicine, London, described eight cases as chronic hyperplasia of the maxilla. Horsley, in 1895, recorded five cases as hyperostosis or leontiasis ossea.

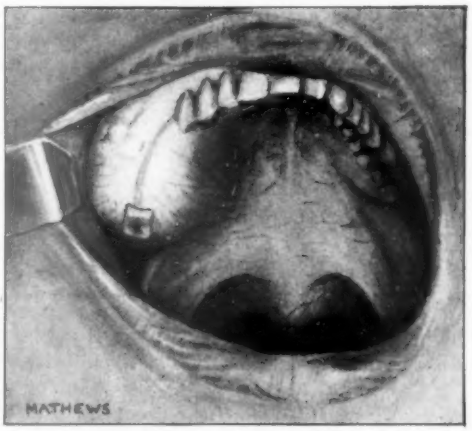

Fig. 1.—Localized fibrous osteoma in a youth (duration five years). The appearance of the tumour from within the mouth. The right upper first and second molar teeth have been extracted. The swelling is confined mainly to the premolar and molar regions. (From "The Benign Fibro-osseous Tumours of the Skull and Facial Bones", by Kenneth C. Eden. *Brit. J. Surg.*, 1939, **27**, 332. Reproduced by permission.)

A study of the notes of 26 cases I have seen during the past twenty-five years shows that the clinical characteristics are a slowly growing, painless enlargement of the alveolus of the molar region of the maxilla commencing early in life, between the ages of 10 and 25. It occurs commonly in females. I have the notes of 19 females and 7 males. In 19 cases the swelling was on the left, in 5 on the right and in 2 cases on both sides. There is no hereditary history. The enlargement is smooth, solid and ill-defined without signs of inflammation and without tenderness. The canine fossa is obliterated and the whole surface of the maxilla is thickened and blends with that of the alveolus. The prominence and accessibility of the alveolus make this enlargement obvious. The enlargement is confined to the outer surface of the alveolus and its inner surface shows no swelling. On the other hand, a tumour expands the whole alveolus, forming more or less a globular tumour in the palate. This distribution of the swelling is a distinguishing feature between a tumour and osteitis. It is often discovered for the first time by the dental surgeon, and the patient does not usually consult a doctor until the swelling has

FIG. 2.—Focal osteitis fibrosa of the left maxilla in a girl aged 21. Duration twelve years.

been present for two or more years. The enlargement slowly increases and its growth is easily estimated when those patients who have to wear a denture find it necessary to have it remade about every two years owing to the steady increase in the size of the alveolus. The X-ray photograph (fig. 2) shows a marked increase in the opacity and thickness of the facial wall of the antrum and a diminution of the cavity of the antrum. The nose and nasal sinuses are normal and in the younger patients there is no dental sepsis. The other bones of the skull are not affected at first. The Wassermann reaction

is negative and there are no indications of acquired or congenital syphilis. The blood-count and blood-calcium content are normal. If a section of the bone is taken, the periosteum is normal and there is an outer compact layer of bone, but beneath it there is soft vascular bone which cuts like a raw potato. The new formation of bone is sub-periosteal in origin and is not clearly defined. The microscopic section shows a typical osteitis fibrosa with increased vascularity and a few giant cells. Some sections have been described as normal new bone. When only a small piece of the enlargement has been sectioned mistaken diagnoses of myeloma and osteosarcoma have been made. This serious error is avoided if the greater part of the tumour is sectioned. The differential diagnosis is not difficult. The smooth, solid, hard and ill-defined swelling of long duration without any inflammation or other physical signs makes the diagnosis obvious.

Tumours, such as an osteoma or fibroma, are much more clearly defined. The X-ray photographs show their limitations and the tumours are more or less encapsuled (figs. 3 and 4).

FIG. 3.—Spherical osteoma of the mandible. The tumour was completely exposed and then enucleated through the mouth.

Osteomata, fibromata, myelomata (fig. 5) and epithelial odontomes are much more common in the mandible and their growth is more rapid. Myelomata and epithelial odontomes are soft elastic swellings, the teeth involved in the tumours are loose and the X-ray photographs are typical (fig. 6).

A dental cyst is recognized by the fluctuating swelling with soft areas situated lower in the alveolus; in some cases there is a discharging sinus. The X-ray photograph is also typical.

The precise pathology of focal osteitis is obscure and the claim that it arises from sepsis or toxic conditions of the teeth or of a nasal sinus cannot be substantiated. When first

FIG. 4.—A fibroma of the left maxilla encroaching on the antrum. A benign tumour was removed eight years previously. This had slowly recurred and was again removed two years ago. No recurrence. White line shows edge of growth.

FIG. 5.—Fibroma of right side of mandible. Encapsuled tumour enucleated through the mouth.

FIG. 6.—Soft myeloma of left mandible. Teeth involved in growth. One loose.

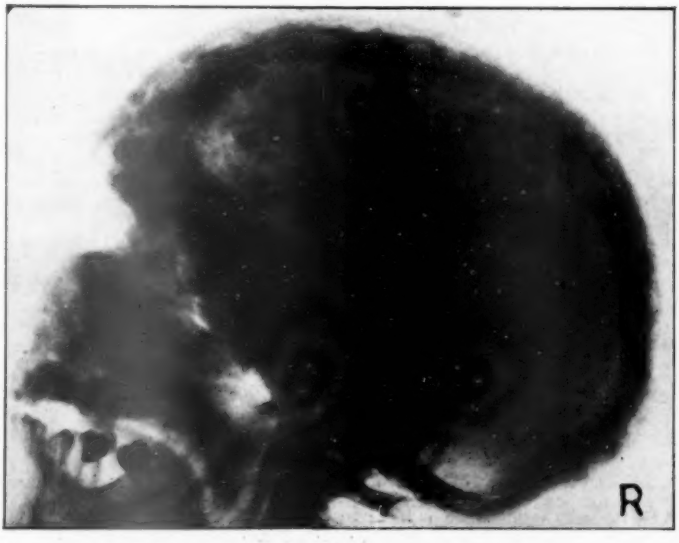

FIG. 7.—A case of leontiasis ossea which commenced as a focal osteitis fibrosa. The patient was under observation for twenty-two years.

seen these patients have perfectly sound teeth with no sepsis and no history of sepsis. The nasal sinuses are also free from sepsis. The extraction of teeth and the removal of sepsis arising after the beginning of the osteitis have not prevented the progress of the enlargement. Moreover cultures taken from normal bone of focal osteitis have been sterile. If the cause were dental sepsis the incidence would be greater. When osteitis has been present for some years dental caries arises in the natural course of events, but cases of osteitis deformans and leontiasis ossea are very susceptible to local necrosis and osteomyelitis of the abnormal bone. There has been no history of local injury in any of these cases.

Evidence has now been obtained to show that focal osteitis fibrosa, osteitis deformans and leontiasis ossea are one and the same disease but that the clinical manifestations vary owing to anatomical or other reasons.

Leontiasis ossea and osteitis deformans are both a form of diffuse osteitis fibrosa which has a predilection for certain bones of the skeleton. Leontiasis ossea affects the bones of the face. Osteitis deformans at first affects the tibia, but there are cases in which the jaws and calvarium are the first to be involved and it is then known as the facial type of osteitis deformans.

X-ray photographs of well-marked cases of leontiasis ossea show precisely the same changes in the calvarium as in osteitis deformans (fig. 7). There are other features which are common to both. Leontiasis ossea is often confined to the surface of the bones of the nose and face. The leonine face develops slowly and takes many years to appear. Lawford Knaggs (1926) has described two forms of leontiasis ossea:

(1) Creeping periostitis;

(2) Diffuse osteitis (osteitis fibrosa).

Leontiasis ossea frequently commences in the tuberosity and nasal processes of the maxilla and extends to the nasal bones and turbinals. It also affects the internal ear like osteitis deformans. Patients suffering from leontiasis ossea first notice the enlargement of the nasal processes and they complain of nasal obstruction and deafness. Two of the 26 cases which I have watched for many years developed well-marked leontiasis ossea, some of the other cases are too young to show evidence of leontiasis ossea.

Three of the 26 cases developed well-marked osteitis deformans. In addition to the early local osteitis of the alveolus the whole of the alveolus and palatal processes of the maxilla slowly increased in size and this enlargement of the jaws in osteitis deformans has been noted by dental surgeons. Osteitis deformans appears to have two stages. The first and early stage is one of decalcification in which the bone is soft, bends easily and is enlarged to compensate for its lack of rigidity. The second and later stage follows when there is an increase in the calcification with an increased deposit of calcium and phosphorus in the bones. It is possible that the two stages blend, i.e. decalcification and compensatory calcification of the bone are in action at the same time. In the first stage the condition is almost identical with that found in focal osteitis of the maxilla. It is assumed that the calcium and phosphorus excretion is increased but in the second stage there is a retention of the calcium and phosphorus. This excretion of calcium and phosphorus is said to be controlled by the parathyroid glands and retention of the phosphorus stimulates the parathyroid glands. So far as is known these forms of focal and diffuse osteitis fibrosa do not have an increase in the blood-calcium or phosphorus. They appear to differ from those cases of osteitis fibrosa or fibrocystic disease with enlargement of the parathyroids and increased calcium and phosphorus excretion described by Donald Hunter, Turnbull (1931) and others. Some pathologists consider that osteitis fibrosa is a disturbance of the many factors which regulate the formation of bone and which depend on calcium and phosphorus metabolism.

Some cases have periods in which the disease is arrested and in others the progress is very slow. There is no successful treatment of osteitis fibrosa at present, but our knowledge of the pathology has improved and given the earliest possible diagnosis with the application of the better understood metabolism of the calcification of bone, a successful method may be devised. Recent researches in the metabolism of calcium and phosphorus and the functions of the parathyroids in relation to osteitis fibrosa and fibrocystic disease of bone indicate such a line of treatment.

Briefly, the results of these researches are:

The normal calcium content of the blood or serum calcium is 10 to 11 mgm. %. The blood phosphorus content is about 3 mgm. %. Blood phosphatase is 0·25%. The two main factors which control the balance of calcium between the serum and the bones are the phosphate content and the parathormone content of the serum. There are other outside conditions which affect the calcium metabolism such as the presence of phosphatase and the pH or alkalinity of the blood. Fibrocystic disease of the bone has been shown to be due to hyperparathyroidism in which there is an increase of calcium of the blood to 16 or more mgm. % and excessive excretion of calcium in the urine. There is also a slight increase of phosphorus in the blood, hence the decalcification of the bone. The parathyroid glands have been found to be enlarged and their removal has resulted in a decrease of the hypercalcæmia and an improvement in the fibrocystic disease. Phosphorus is said to stimulate the parathyroid glands to increase the amount of calcium phosphate excreted in the urine. Phosphatase is an enzyme which hydrolyses organic phosphates into inorganic phosphates and it occurs at the principal sites of phosphate metabolism, namely, the intestinal mucosa where phosphorus is absorbed, in the bones where it is stored and in the kidneys where it is excreted.

Further details of this interesting research in biochemistry can be found in a paper by Hermon Taylor (1934); also a paper by A. J. Helfet (1940).

Focal or diffuse osteitis fibrosa as seen in osteitis deformans and leontiasis ossea shows no increase in the blood-calcium or increased excretion of calcium in the urine and there is no evidence that these forms of osteitis fibrosa are due to hyperparathyroidism. It is assumed that focal osteitis fibrosa is due to a decalcification of the bone, as in the first stage of osteitis deformans. I have prescribed calcium gluconate by the mouth in two cases and also advised a much increased milk consumption but owing to the war I have not been able to observe the result. Helfet adopts the theory that an accumulation of phosphate in the blood stimulates the secretion of parathormone and he states that in the later and second stage of osteitis deformans there is a retention of calcium and phosphorus. It is impracticable to reduce the phosphorus intake in an adequate diet so the reduction of the phosphorus was obtained by the administration of a soluble salt of aluminium. The aluminium combines with the phosphates in the intestine, precipitating insoluble aluminium phosphate which is excreted unchanged in the bowel. Helfet's prescription is:

Liq. Aluminium Acetate ℥ 1¼
Syrup ʒ 6
Ess. Cherry Conf. Opt. ♏ 4
Mel Depuratum (P.B.) ad ℥ 4

ʒ 1 four times a day after food.

This is combined with at least one pint of milk a day.

He has treated eight cases of osteitis deformans successfully with the result that they could walk farther and do more without being tired. Bone pain became less frequent and less intense. In two cases controlled radiographs suggested a slow change towards the normal. If the administration of soluble aluminium is tried the patient should be carefully observed, though Helfet has given two patients aluminium acetate continuously for a year without any toxic reaction or gastro-intestinal upset.

In my opinion, surgical treatment should be avoided, but I have been persuaded to remove the deformity for 2 young patients and I have seen the results obtained by other surgeons. The enlargement is very diffuse and extends to the infra-orbital margin, also the whole of the facial wall of the maxilla was uniformly thickened. In spite of the removal of a large quantity of the soft bone from the surface of the maxilla the cosmetic result was not good. There is also the risk of sepsis and an exacerbation of the progress of the condition. Excision of the maxilla is decidedly unnecessary and the mutilation and deformity of such an operation are unjustifiable.

Summary

(1) Focal osteitis, leontiasis ossea and osteitis deformans are forms of one and the same disease.

(2) Neither dental and nasal sinus sepsis nor traumatism is the cause of the condition.

(3) The abnormal bone produced by osteitis fibrosa is more susceptible to osteomyelitis, necrosis and local secondary sepsis than the normal bone.

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Discussion.—E. W. FISH (representing Mr. W. Stewart Ross, Section of Odontology) said that he agreed with Mr. Davis that osteitis fibrosa was not associated with dental sepsis or sepsis of any other kind. Among Mr. Davis's specimens was an endosteal myeloma of the jaw, a condition which was not described, though he had always suspected that the myelomas of the jaw started as an endosteal tumour. He did not find any satisfaction in the theory that the altered calcium or the phosphorus content of the blood was the cause in cases of osteitis fibrosa. He knew that it was not altered in the local variety, and that in the generalized it certainly was, but the alteration was the result of bone destruction, not the cause. Experimentally it was quite easy to give doses of parathormone and produce a great loss of bone from the skeleton, but on studying the bone it was found that cellular activity rather than blood chemistry was concerned. Bone was spoken of as being decalcified or as undergoing increased calcification, but that was not an exact description of what was taking place, for the bone, both the organic as well as the inorganic fraction, was either being eaten away entirely or alternatively more bone was being built, but in either case what remained was as much calcified as before. When the X-ray picture showed increased opacity it signified that there was actually more matrix present, not that what was there was more heavily calcified.

He illustrated by means of a few slides examples of cell activity which had brought him to these conclusions, and mentioned an experiment in which a guinea-pig was subjected to the introduction of thymol into bone. He showed a section of the symphysis menti of the guinea-pig in which the thymol had gradually impregnated the bone. The result showed that in the area where the irritant was most concentrated the bone lacunæ were empty and the bone cells had been killed. Where the concentration was less the bone was being eaten away by osteoclasts, while further away still, where the poison was still more diffused, an enormous amount of new bone was being built, even within a period of forty-eight hours. There was an ordered action in response to the irritant.

The reason why he felt that osteitis fibrosa and leontiasis ossea were neoplastic just as bone tumours were, was because the cells did not act in any way which conformed to the rule that bone was absorbed where the irritation was greater and deposited where it was less. It was an absolute rule. If it were not so, sequestration of bone could not occur; but the activity of the cells in bone and tooth tumours showed that they were not acting in response to any law by which bone was normally absorbed or deposited.

He illustrated this difference in cell activity with sections of tooth lesions similar to osteitis fibrosa in bone. One of these had arisen from the pulp of a tooth and so could not have taken origin from either osteoblasts or osteoclasts since neither of these cell types is normally present in the pulp. He thought that the undifferentiated mesenchyme cell which is present in both bone and dental pulp was responsible for these lesions and regarded them as neoplastic because they could not be attributed to any apparent cause, served no useful purpose, but were examples of disordered cell growth having no typical termination.

KENNETH EDEN said that this was a subject of which he had recently made a study, and he had come to the conclusion that " hyperplasia of the maxilla ", or " fibrous osteoma " as he preferred to call it, was one of a number of allied conditions found

in the membrane bones of the face and vault of the skull; they did not occur in the base of the skull.

The more fibrous of these tumours were found in the jaws as a central form—" the central ossifying fibroma ", and a periosteal form—" the fibro-osseous epulis ". They were composed mainly of new fibrous tissue, but always contained areas of ossification, and frequently a curious type of calcification in spheroids. These " calcium spheroids " were also seen in the osteomas of the skull and facial bones. The ossifying fibromas were uncommon in the bones of the cranial vault, but he had seen one tumour of this type in the frontal bone.

The form about which Mr. Davis had been talking, the fibrous osteoma, was found in either jaw, though more commonly the maxilla, and the cranial vault. It was characterized by a spongy network of new bone formation in fibrous tissue, replacing a part or the whole of one bone. There was also a more widespread form involving several bones, which corresponded to the " osteitis fibrosa type of leontiasis ossea " described by Lawford Knaggs; this had to be distinguished from the periosteal form of leontiasis, which might well be inflammatory in origin.

Finally there were the ivory osteomas composed of dense new bone with a scanty fibrous tissue basis.

Pathologically all these types were related and had certain features in common. Transitional forms were also occasionally found. There was no evidence that they were inflammatory in origin, and he believed that they should be regarded as benign new growths.

" Osteitis deformans " was a disease occurring later in life than these other conditions, which arose during the growing period, and was usually in the end a more or less generalized disease, though it might be localized to a few bones for a long time. While it commonly involved the bones of the cranial vault, it tended as a rule to miss the facial bones, though there were on record a number of cases of a facial type of the disease. He thought that this disease could not be proved to be the same condition as the diffuse osteomas of the skull and facial bones.

The CHAIRMAN (Douglas Guthrie) said that very little work seemed to have been done on this subject during the past few years; the problem was that of classifying these curious bone tumours and deciding whether they had previously been classified too diffusely, using too many names, or whether they belonged to only one or two groups. It seemed possible that there were two groups, one of septic origin and another possibly of neoplastic origin, but certainly not inflammatory.

In favour of a septic origin in some of these cases was the curious tropical disease known as " goundou " in which the ascending processes of the maxilla enlarged, and the patient appeared to have two large egg-shaped swellings, one on each side of the root of the nose. This was illustrated in many works on tropical diseases, but he had asked quite a number of medical men who had been in West Africa, none of whom had seen a case. It was first described by Macalister, in 1882, who alleged that he had discovered a race of horned men in West Africa. The supposed " horns " were so common that almost every person in the tribe was affected. It appeared to commence with nasal discharge in childhood and later the swelling appeared. Was this condition allied to those diseases which had been discussed that afternoon?

The problem of hyperplasia of the cranial bones was not by any means purely of academic interest; it might even yield a clue to the nature of otosclerosis. The close resemblance, histologically, of hyperplasia of the maxilla to the new bone formation in otosclerosis had been noted by Albert Gray and other observers, and by trying out various remedies something which would influence otosclerosis might possibly be discovered, and this would be a very great advance.

The slides he had to show illustrated a paper which he had communicated to the Section some years previously (*Proc. Roy. Soc. Med.*, **16**, Sect. Laryng., p. 73). The first was a well-known skull illustrated in various textbooks, first shown by Bickersteth of Liverpool to the Pathological Society of London in 1866. All the bones were affected with the exception of the nasal bones. The orbits were encroached upon, and the patient was blind. He died aged 34. The lower jaw was enormously enlarged by bossy formations. The next was a case of Beck's, which illustrated the appearance and showed why the condition received the name of leontiasis ossea. The patient had the leonine appearance, also clubbing of the tips of the fingers. Another illustration was from a paper by Westmacott, one of the earlier papers on the subject (Internat. Congress, 1913),

showing the soft and cancellous bone on section, and the general thickening of the alveolus, very similar to the casts handed round that afternoon.

There were only two specimens in the Royal College of Surgeons Museum in London. One was a jaw removed by Mr. Christopher Heath, and noted in his book on " Diseases of the Jaws " (1884). This one showed very well how the antral cavity had been encroached upon and had become very small. Another slide was of historical interest; an upper jaw which had been removed by Lord Lister, also under the impression that he was dealing with a malignant condition. Here again the maxillary sinus was reduced to very small proportions.

Section of Therapeutics and Pharmacology

President—Sir William Willcox, K.C.I.E., C.B., C.M.G., M.D., F.R.C.P.

[*February* 11, 1941]

DISCUSSION ON CHEMOTHERAPY AND WOUND INFECTION

The President said that it was almost incredible that less than six years had elapsed since Domagk discovered the two dyes which inhibited or prevented the development of streptococcal septicæmia. This was very quickly followed by the work of Colebrook, Buttle, O'Meara, and many others, and the knowledge had spread rapidly all over the world. Since the war the diffusion of this new knowledge had been accelerated. The discovery of the sulphanilamides and their use would rank as one of the greatest discoveries of this century; certainly it was one of the greatest chemotherapeutic discoveries, parallel with that of salvarsan discovered in 1909. Most of these drugs had a rather poor action *in vitro*, but they acted in collaboration with the body fluids by controlling infection, exercising, to use a word which was much in the vogue thirty or forty years ago, an opsonic action on the germs and rendering them an easy prey for the leucocytes.

These drugs were first applied to infections caused by the hæmolytic streptococcus, but they were soon found to have an action on meningococci, staphylococci, pneumococci, and typhoid organisms, also on some protozoa, and they appeared to have some action on viruses.

When the nucleus was modified by adding side chains and so on, the action of the drug was modified also. If pyridine were added a substance was obtained with a more specific action for the pneumococcus. If thiazole were added another modified action was obtained, namely a greater specificity in action against the staphylococcus.

Colonel Leonard Colebrook: When the German workers in 1935 reported that red prontosil, when given by the mouth, was able to protect mice which had received a fatal dose of streptococci into the peritoneum—and at the same time that this red prontosil had little or no action in the test tube upon the same streptococci—it looked at first sight as if this drug was not going to be of much value to us as an external antiseptic. It seemed possible that the therapeutic effect was an indirect one—being due to some activation of the antibacterial mechanisms of the body. In keeping with that view was the fact that when patients recovered from puerperal fever or tonsillitis under the influence of the drug the streptoccoci did not promptly disappear from the local focus—they could often be cultivated for two or three weeks afterwards.

Later it was shown that red prontosil was reduced in the body to the colourless compound p/amino-benzene sulphonamide (sulphanilamide) and that substance, unlike the parent red dye, had a considerable bacteriostatic effect upon streptococci *in vitro*. A direct action of the drug upon the infecting organisms was, therefore, quite possible, and indeed now appears almost certain.

Following upon this we learned that sulphanilamide was an extremely diffusible substance, as evidenced by the fact that it gets very quickly into the cerebrospinal fluid, the vitreous and aqueous humours, and all the tissues of the body. Further, unlike most

of the older antiseptics, it has a very low affinity for body tissues and for serum proteins. Practically all the older antiseptics were quenched by contact with blood or body tissues. But this is not the case with the sulphonamide compounds, as evidenced by the fact that almost all (80 to 90% or even more) of the dose administered is ultimately excreted; and by the fact that they have proved remarkably innocuous to tissues (fibroblasts) growing *in vitro*, and also to leucocytes (phagocytic and bactericidal tests). Finally, these compounds are readily absorbed from wounds—and, after absorption, can therefore reach any organisms in the tissues at a distance from the wound cavity.

All these properties, combined with the fact that they have a direct effect upon the streptococci and other susceptible organisms—interfering with their reproductive activity—make it likely that sulphanilamide and its derivatives will be found to have considerable value in certain circumstances as external antiseptics.

Of the intricate chemical processes that occur in any wound we know very little, but there is one aspect of wound pathology upon which great stress was laid by Almroth Wright and Fleming in the last war, namely, that every wound produced by violent injury is really a honeycomb of "dead spaces"—spaces between muscle bundles, in the subcutaneous tissue, fascial planes, &c.—and these spaces inevitably become filled with serous fluid, which is an extremely good culture medium for certain pathogens, the commonest being staphylococci and streptococci.

Until recently, we had no means of changing that congenial culture medium in the dead spaces into an uncongenial medium. We had no antiseptic which would remain in the wound and retain its bactericidal properties for a number of hours. But the coming of sulphanilamide has changed all that. Powdered sulphanilamide introduced into a wound will slowly dissolve in the exudate, giving a nearly saturated solution which may be expected to check the growth of most bacterial species. (Exact data as to the actual concentrations of the drug in the exudates, and observations on their growth-inhibiting power on various pathogens, are not yet available and should be obtained.)

It is not yet known if such a strong solution may not have some harmful effect on the leucocytes in and about the wound. Up to about 1:400 sulphanilamide solution has no such effect but I am not aware of any tests with stronger solutions. It is quite possible that some injury to leucocytes will occur during the first few hours but it is also possible that this disadvantage will be offset by the inhibition of bacterial growth. My own *in vitro* experiments lead me to suppose that if a moderate number of hæmolytic streptococci are implanted into the fluid of "dead spaces" there is a very good chance that they will be killed off completely by the drug even without the co-operation of active leucocytes. If, on the other hand, staphylococci or gas gangrene clostridia, or coliform bacilli, are implanted in the wound, their destruction without the aid of leucocytes is much more doubtful. It is indeed possible that their multiplication will not be effectively checked.

We can only find out how much will actually be achieved in the average wound by bacteriological examinations from day to day on groups of approximately comparable wounds, treated by similar surgical procedures, but some with and some without added sulphanilamide.

Meanwhile we have some clinical data, and some derived from experimental work on animals to guide us. The first were obtained by Jensen and his colleagues (1939) at St. Louis. In their interesting paper they claimed that no less than 39 out of 41 consecutive compound fractures had healed by primary union without suppuration following the liberal application of sulphanilamide powder at the time of débridement. This work came to the notice of Legroux (1940), Nitti and Tréfouël who were quick to realize its possible importance in connexion with wounds of this war. They saw that, owing to aerial warfare, there might be great difficulty in the evacuation of the wounded and therefore great need for a "pansement d'attente"—a delaying dressing which would hold up bacterial growth for some hours and so prolong the safe period in which the surgeon could carry out an adequate excision. In order to get evidence as to the value of local chemotherapy for this purpose these workers produced experimental wounds in animals, crushing muscles and then infecting the wounds with streptococci or gas gangrene bacilli. Their results showed clearly that dusting the wounds with sulphanilamide, combined with surgery only to the extent of removing the foreign body by which the infection has been conveyed, was able to save a large proportion of the animals.

These pioneer investigations seem to give promise of advances both in the prevention and treatment of wound infections. By the early application of one of these compounds we may hope, I think, to prevent the development of gas gangrene in many cases, but not in all. We may hope to prolong the safe period for the careful surgical exploration and excision which has been found so important for the avoidance of wound sepsis. Following such surgical intervention, and the application of sulphanilamide, primary or delayed primary suture will probably be successful in many of the less severe flesh wounds—particularly the multiple wounds so often seen in air-raid casualties. And in compound fractures treated by the closed plaster method we may hope sometimes—perhaps often—to get recovery without suppuration.

At present all severe deep burns—and also many that are not very deep—become infected under the usual coagulant (or any other) treatment; and the sepsis resulting increases the amount of tissue damage, delays healing, and gives rise to serious contractures. We cannot be satisfied with that situation. Our aim must be to keep a burn uninfected throughout, and where there is extensive loss of skin, to graft at an early date. Our best hope of doing this lies in sulphanilamide or one of its derivatives; and the immediate task is to find out which of these it is best to employ, and how to use it—as powder, or paste, or solution, or incorporated in an occlusive dressing of some kind with a view to the prevention of fluid loss from the burned area. We are at work on that problem now. It may be that the solution will be found not in a sulphanilamide derivative but in penicillin or one of the other rather mysterious antibacterial substances which we can obtain at present only from moulds or certain bacteria.

As to the local chemotherapy of established wound infections, my colleagues Purdie and Fry (1937) were the first in this country to report the use of sulphanilamide powder for the treatment of a chronic superficial streptococcus infection. Since they gave the drug by the mouth as well it is not certain, however, how much of the dramatic result was due to the local therapy.

Recently, with Major Francis and with the co-operation of Sir Harold Gillies and his colleagues at Basingstoke, we have observed a large number of wounds dusted daily with sulphanilamide powder. It seems quite clear that, if there is not very much exudate nor any pocket in which it collects, one can usually get rid of hæmolytic streptococci from such wounds within three or four days.

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Mr. Emlyn E. Lewis: The local application of sulphanilamide compounds may be divided into two groups: (*a*) Wounds; (*b*) Burns.

(*a*) *Wounds.*—In addition to oral administration of M & B 693 all wounds are treated with sulphanilamide compounds, we use streptocide. After excision of the wound and hæmostasis has been obtained streptocide is applied to the whole wounded area. At first we used to insufflate the area but now we prefer to work the powder over the area with the finger until a uniform layer is obtained. We have not used any prescribed amount of streptocide but sufficient to cover the wound. In many instances we have used more than 15 grm., while in others less has been used. After this application the wound is lightly packed with plain gauze or vaseline gauze, or, where suitable, primary suture performed, burying the powder in the depth of the wound. We have not noted ill-effects arise as a result of this latter procedure.

As a rule the wounds are not inspected before the fifth day and at this time the majority are healthy in appearance with surprising absence of infection. In quite a number of cases at this stage, after further application of powder, we have obliterated the depth of the wound with a few catgut sutures. In one case only have we felt justified in performing secondary suture during the first week. It was this same patient who was the only one to show powder still present in the wound on the fifth day. He had had a very liberal application in the first place. I will refer to him again.

We have encountered three cases of gas gangrene, two of which were compound fractures who had had M & B 693 four-hourly for forty-eight hours and a liberal application of streptocide to their wounds. Both developed gas gangrene on the third day. The third case occurred in a man who had received a through and through wound of the left thigh. At operation twelve hours later he was found to have gas gangrene. A wide surgical excision was carried out and streptocide was applied very liberally to the wound. On recovering from the anæsthetic he was given M & B 693, 2 grm. four-hourly for forty-eight hours. No anti-gas serum was given at any time. Inspection of the wound on the fifth day showed it to be healthy. There was no clinical evidence of infection. The wound was again powdered and the depth of the wound obliterated by a few catgut sutures. On the eighth day secondary suture of those edges of the skin which could be approximated was performed and the remaining area skin-grafted at a later date.

(*b*) *Burns.*—We have used streptocide powder in the primary treatment of burns of the second and third degrees. No M & B 693 has been given orally to these patients. The usual burns so treated have been those of the face, forearms and hands.

After preliminary cleansing with soap and water and removal of loose skin, 70% spirit is applied to the burnt area and surrounding skin. This is dried off and streptocide powder applied to the burnt area. It is covered with tulle gras. Sometimes foille is first applied and then streptocide with tulle gras. The results have been most encouraging. We usually inspect the dressing on the fifth day when a further application of streptocide is made.

A girl with burns of one side of the face was able to discontinue dressings on the fifth day. Another case of burns of the whole of the face, forehead and both surfaces of both ears and neck was able to discontinue dressings on the twelfth day. The face was completely healed and the skin quite normal in appearance. This same patient had a degloving of the left hand. It was at first treated with sodium bicarbonate baths and compresses but on the fourth day showed obvious infection. It was insufflated with streptocide and covered by tulle gras. Twice daily the surface of the tulle gras was insufflated. The hand was completely healed on the fourteenth day. Another case of burns of the thighs, vulva, perineum and buttocks treated with streptocide was healed on the twelfth day. A case of burns of the trunk which was at first tanned became septic. Streptocide was applied after the tan was removed and prior to skin grafting. Hæmolytic streptococci were known to be present in the pus. After five days of streptocide the area was free of streptococci. Skin grafting was performed successfully. The same case showed toxic symptoms similar to those following oral administration of sulphanilamide compounds. This was the only one with toxic symptoms, despite the local application of the powder to a number of cases.

Mr. R. Mowlem: Most of the work which forms the basis of this paper has been done at a Unit of the E.M.S. Maxillo-Facial Service in co-operation with Dr. Spooner, who is carrying out a close bacteriological control of the whole Unit. The type of patient in our wards is the bombed civilian and the Service casualty requiring plastic repair. Many of these patients need skin grafting and though I have used sulphonamide for a very great number of other patients, I shall deal only with the graft cases. Burns and extensive lacerations are the chief cause of a tissue loss calling for grafting. Since we are a specialized Unit and since many of our patients suffer from a multiplicity of injuries, they do not reach us for some time after the date of injury. This means that even under optimum circumstances they are heavily infected upon admission. At the beginning of December 1940, hæmolytic streptococci were obtained in culture from 75% of the ward population. A great majority fortunately do not exhibit clinical evidence of this invasion and in most instances the organism may be regarded as saprophytic. At the same time its presence precludes or at least vitiates surgical interference and is a potential source of infection to others. The figure given above is perhaps much higher than would be shown in a general surgical ward, and this must be due to the type of injury we treat. If then chemotherapy can effect improvement under these circumstances, it should be even more efficacious in a ward occupied mostly with cases of closed wounds.

In the past we had come to rely largely upon the creation of an optimum condition of the granulations whereby the body itself was enabled to bring its bacteriostatic forces into play to enable grafting to be carried out. We had not found that antiseptics were of very

great value. This may be due to the actual structure of the granulation tissue, which in its exuberant state is rather like a sponge so that deep penetration is made difficult. The surface is indifferently supplied with blood and forms an almost ideal nidus for infection. Serous transudation is fairly free and may have some considerable effect in buffering any antiseptic applied at the usual infrequent intervals. We had therefore concentrated upon reducing the exuberant mass to a smooth flat, dry layer of pink granulations which presented less opportunity for bacterial growth, by the use of pressure bandages applied over tulle gras and saline. The saline was sometimes double strength, but usually normal. Occasionally, eusol or spirit was applied frequently over a short period and in addition the local vascular supply was improved by ultra-violet radiation through sterile liquid paraffin. After a fairly long period, measured usually in weeks rather than days, the desired conditions were sometimes achieved. Then, and not until then, was grafting considered to have the optimum chance of success. In 1937 Rank reviewed a series of about 300 cases of this type, operated upon by five surgeons of whom I was one. Our methods were so similar as to make variations in technique unlikely to have an appreciable bearing upon the individual results. In that series, only 16% showed a 100% take, and an additional 27% showed between 75% and 100%. The percentage of complete failures was high.

When we were confronted with the extensive burns, and other lesions associated with warfare, this state of affairs became serious. One could visualize numbers of our beds occupied by casualties patiently accumulating fibrous tissue which would ultimately be removed surgically, whilst we impatiently awaited the control of their sepsis.

We have used Colonel Colebrook's technique in applying sulphanilamide to wounds as a basis ; we have elaborated a few variations. Ordinary agents, such as saline, sodium sulphate, eusol or peroxide, are used to create some degree of local cleanliness in the wound. This is usually a matter of two or three days. My impression is that the use of sulphonamide from the very beginning on a dirty wound may actually slow the rate of separation of sloughs presumably by decreasing the histolytic effect of pus. When the area is reasonably clean sulphonamide powder is applied daily beneath a layer of tulle gras and saline. If the powder be gently massaged into the wound with a spatula, pus formation ceases a little earlier than when the sulphonamide is powdered on to the surface. So far we have had but few patients who showed a sterile culture after three or four days of this treatment, but this has not deterred us from grafting. On the morning of operation the patient is given 2 grm. of sulphonamide by mouth two hours before being taken to the theatre. On the operating table he is given 5 c.c. of soluseptasine. The granulations are excised (this necessarily exposes fresh tissue spaces), bleeding is controlled and the whole surface fairly heavily coated with sulphonamide, which is gently massaged into a paste with the serum in the wound. Care is taken to avoid coagulated masses of the powder. The whole area is next completely covered by the graft and the usual pressure dressings applied and maintained for seven days. Upon returning to the ward sulphonamide is given at the rate of 1 grm. four-hourly for thirty-six hours.

We have had only one failure, which might have been caused by infection, and the number of cases is getting on into the forties. None of the others has been less than a 75% take, and most are above that figure. In the case which did fail the usual addition of sulphonamide by mouth had, unfortunately, been omitted.

In no case has there been any evidence of local cellulitis or systemic infection. Since most of the recipient areas were subjected to some kind of surgical trauma, usually the excision of granulation tissue, in the presence of a known hæmolytic streptococcal infection, it would appear that the infections are definitely controlled. In my previous experience reactions were frequent ; this meant not only an ill patient, but also a poor or a negative surgical result. The presence of the layer of sulphonamide beneath the graft does not jeopardize its take, though I admit that I had misgivings with the first few cases.

The blood concentration of sulphonamide does not appear to rise unduly high. Figures in the region of 3-4 mgm. per 100 c.c. are perhaps average.

Finally I shall refer to some four cases giving good results despite the initial unsatisfactory condition. The first two are blast burns of the first and second degree, admitted within twelve hours of injury and showing at the end of a further twenty-four hours gross infestation with hæmolytic streptococci. These patients were treated with saline

packs applied over sulphanilamide powder. The third case is that of a distinguished airman burned some three and a half weeks prior to his admission. At that time he was grossly infected and was subjected to daily dressings of sulphonamide for about a week. His infection had then decreased clinically, but the organism was still recoverable. We grafted the right upper lid and forehead, removed the gangrenous tips of two of his fingers, and grafted them at the same operation. In spite of this there was at least a 75% take. There have been numerous other instances of the same results; one in particular which stands out being a man, all of whose fingers and thumb were avulsed by machinery, together with the skin of the palm and the dorsum almost up to the wrist. The mangled remains had been encased in plaster for ten days before he came to us. In spite of a heavy bacterial growth, we grafted him within four days, and seven days later the whole area was completely epithelialized with the exception of two exposed metacarpal heads and an adherent flexor tendon.

These results are so spectacular that unless we have yet to encounter an enormous series of failures, the use of sulphonamide marks one of the greatest advances yet made in enabling the surgeon to reapply the finest of all dressings—a layer of the patient's own epithelium before fibrosis and contractures can occur.

Professor Alexander Fleming: Sulphanilamide was introduced for the treatment of *Streptococcus pyogenes*, sulphapyridine (M & B 693) followed it in connexion with pneumococcal infections, and later sulphathiazole has appeared in connexion especially with staphylococcal infections. Because of this sequence it is a common opinion that sulphanilamide is the drug of choice for streptococcal infections, sulphapyridine for pneumococcal, and sulphathiazole for staphylococcal infections. This is not quite true, and it is more accurate to say that while sulphanilamide is sufficiently bacteriostatic to deal with most *Streptococcus pyogenes* infections, it fails with pneumococcus and staphylococcus; sulphapyridine is more powerful, so that it will act on pneumococci as well as streptococci, but it fails in staphylococcal infections; sulphathiazole has a more powerful action than sulphanilamide or sulphapyridine on both streptococcus and pneumococcus, and is so potent that it can influence staphylococcus infections as well. *In vitro* experiments in the laboratory support this view.

If we compare the bacteriostatic power of sulphathiazole with sulphapyridine in human blood we find that the former is considerably more potent, not only on staphylococci but on other microbes, including hæmolytic streptococci and pneumococci.

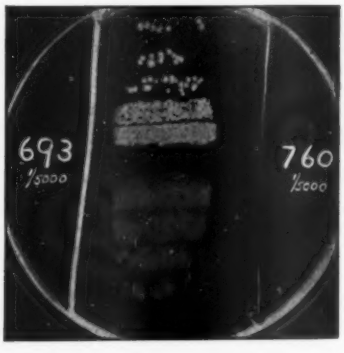

FIG. 1.—" Impregnated strip " method of testing the inhibitory power of chemicals. The left side of the plate contains agar impregnated with sulphapyridine, while the right side contains sulphathiazole agar. Dilutions of two strains of *B. coli* planted in streaks across the plate.

Note: (1) Increased area of inhibition with sulphathiazole. (2) Increased area of inhibition when inoculum is small.

A simple way of comparing two such drugs is by cutting strips from a culture plate of agar, blood-agar, or other medium, and filling the cavities thus left with agar containing a certain concentration of the drug. Then suitable dilutions of bacteria are spread in streaks between the two "impregnated strips" (fig. 1). The drug diffuses into the culture medium and inhibits the growth of the bacterium up to a distance of 2 cm. or more. Things like rate of growth of the bacteria have to be taken into account in comparing the sensitivity of different bacteria tested by this method, but this does not affect the results obtained with one microbe tested on two drugs, as along the whole length of the streak it is growing on the same medium, and the only varying factor is the drug which has diffused into the medium.

(This rate of diffusion into a culture medium may be of some importance in testing the efficiency of these drugs, for therapeutic purposes. I had the opportunity of testing a new sulphonamide compound which, when tested in blood, showed rather more bacteriostatic power on streptococci and pneumococci than did M & B 693. However, when tested in the above manner on a blood-agar plate its inhibitory power was negligible, and when tested on mice it proved ineffective in the treatment of experimental pneumococcal and streptococcal infections.)

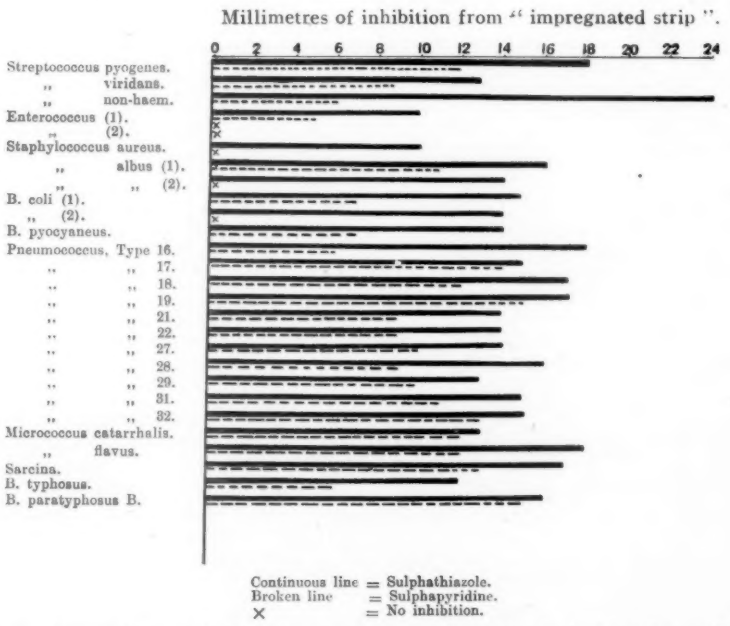

FIG. 2.—Comparison of the inhibitory power of sulphathiazole and sulphapyridine.

In fig. 2 are set forth the results obtained in this way with sulphathiazole and sulphapyridine on a variety of bacteria, from which it can be seen at a glance that sulphathiazole is the more inhibitory drug on every one of the bacteria used (including those commonly found in infected war wounds). With *Staphylococcus aureus* and some enterococci sulphapyridine in the strength used does not inhibit, while there is marked inhibition with sulphathiazole.

The solubility of a chemical may be of the greatest importance, especially for local application. For instance, sulphanilamide is soluble to the extent of about 1%, and sulphathiazole only about 1:2,500. If, therefore, sulphathiazole were 25 times more

bacteriostatic than sulphanilamide (as it is) the saturated solutions of these two would be about equally potent.

The importance of the rate of absorption and excretion is obvious, and part of the routine in the treatment of these patients should be periodical estimations of the sulphonamide content of the blood, just as estimation of the blood-sugar content is part of the routine in the control of diabetes. The test is not difficult, and it gives valuable information as to whether the patient is absorbing the drug in sufficient quantities. We know how much of the drug the patient takes, but it is only by such an examination that we know how much is being absorbed.

I have always been very much against the indiscriminate use of chemicals labelled as antiseptics in septic wounds. In 1924 I introduced a test in which the chemical acted on bacteria in human blood. If the chemical inhibited leucocytic function more than it inhibited the growth of the infecting bacteria I regarded the chemical as unsuitable for use in a septic wound (as an antiseptic), and unfortunately all the antiseptics in common use up till recently have come into this category. Sulphanilamide (and the other sulphonamides) pass this test with honours, as they only affect leucocytic function in concentrations much greater than can be obtained therapeutically in the blood, whereas a small fraction of such concentration is sufficient to inhibit the growth of a sensitive bacterium.

By this test alone it might be expected that the sulphonamides would be successful as local applications to septic wounds, and so it has proved with limitations. Before the war started and made us think again in terms of war wounds, it had been shown that the action of sulphanilamide was inhibited by large numbers of bacteria and bacterial extracts (Fleming, 1940), (Stamp, 1939), peptone (Lockwood, 1938), and some chemicals of similar constitution, e.g. p-amino-benzoic acid (Woods, 1940). More recently it has been found that pus fluid has the same inhibitory action. Table I shows the inhibitory action of pus fluid on sulphapyridine. Pus from an empyema, and containing a few pneumococci, was centrifuged and the supernatant fluid was heated to destroy any living cocci. Serial dilutions of the fluid were mixed with an equal volume of human blood infected with staphylococci and containing 1:20,000 sulphapyridine, and incubated in slide cells. From the table it will be seen that a dilution of 1:64 of the pus fluid completely inhibited the bacteriostatic power of the sulphapyridine.

TABLE I.—EFFECT OF PUS FLUID ON THE BACTERIOSTATIC ACTION OF SULPHAPYRIDINE.

Infected blood containing 1 : 20,000 sulphapyridine plus an equal volume of pus fluid	Number of colonies developing
Undiluted	43
1 : 2	43
1 : 4	41
1 : 8	39
1 : 16	32
1 : 32	40
1 : 64	26
Control (saline substituted for pus fluid)	0

The inhibitory action of pus fluids and other body fluids has been investigated by McLeod (1940).

I pointed out in an address to the Odontological Section (*Proc. Roy. Soc. Med.*, 1940, 33, 127, Sect. Odont., 23), that these factors would limit the use of sulphanilamide in the frankly septic wound, and so it has proved in practice. However, in the recently inflicted wound these inhibiting factors do not exist, so that theoretically sulphanilamide should be valuable as a bacteriostatic agent, and apparently it is. Colebrook has just shown us that in old granulating wounds, clean but infected, sulphanilamide applications rapidly get rid of hæmolytic streptococci. In such wounds, also, the inhibitory factors do not exist to any extent.

There is another class of compound which threatens to be a serious rival to the sulphonamides. Some eleven years ago I described a substance which I named penicillin, which was produced by a particular mould (a penicillium) in the course of its growth on ordinary culture medium. The broth on which the mould had grown would even when diluted some 1 : 500 to 1 : 800 times, inhibit the growth of organisms like staphylococci, streptococci,

or pneumococci, while it had practically no inhibitory effect on some other organisms such as *B. coli, B. pyocyaneus, B. influenzæ,* &c. About 1930 it was used as a dressing on a few septic wounds with favourable results, but as in peace time septic wounds are uncommon in hospital, and as the potency of penicillin rapidly disappeared on keeping the therapeutic aspect of this substance was dropped; but it has been in constant use in the laboratory for the isolation of *B. influenzæ* and *B. pertussis* from the midst of a mass of streptococci or pneumococci.

Recently Chain and his associates (1940) at Oxford have succeeded in extracting from cultures of this mould a solid substance containing the active principle mixed with a considerable amount of pigment and other inert materials. This impure penicillin they have shown to have remarkably curative properties in mice experimentally infected with staphylococcus, streptococcus and *Vibrion septique.*

I obtained some of this impure penicillin from the Oxford workers, and have compared its bacteriostatic powers with those of sulphathiazole, and sulphapyridine. Table II shows some of the results obtained with *Staphylococcus* and *Streptococcus pyogenes* (the two most common infections of septic wounds). It will be seen that, weight for weight, penicillin is four times as potent as sulphathiazole, and about twenty times as potent as sulphapyridine. (This should make it about one hundred times as powerful a bacteriostatic as sulphanilamide.)

TABLE II.—COMPARISON OF THE BACTERIOSTATIC POWER OF PENICILLIN, SULPHATHIAZOLE AND SULPHAPYRIDINE IN HUMAN BLOOD.

	Smallest concentration showing no growth
I. *Streptococcus pyogenes.*	
*Penicillin	1 : 800,000
Sulphathiazole	1 : 200,000
Sulphapyridine	1 : 50,000
II. *Staphylococcus aureus.*	
*Penicillin	1 : 320,000
Sulphathiazole	1 : 80,000
Sulphapyridine	1 : 10,000

* Impure Penicillin. More than half of the solid consists of inert substances.

Penicillin has an advantage over the sulphonamides in that it is not inhibited by large numbers of microbes, or by pus fluids.

This impure penicillin possibly contains not more than 30% of the active principle, so that one can easily see the possibilities of such a chemical if it could be identified and prepared on a large scale.

More recently in America antibacterial substances have been extracted from cultures other than my penicillium. Dubos (1939) prepared from a soil bacterium a substance which he has called Gramicidin, which had powerful antibacterial effects on all Gram-positive organisms. McDonald (1940) has extracted from a considerable number of bacteria, including *B. subtilis* and *B. mesentericus,* a substance having strong antibacterial properties. White (1940) found an aspergillus which produces an antibacterial substance, which he has called "Aspergillin." Waksman and Woodruff (1940) have described a crystalline substance which they extracted from cultures of a soil actinomyces, and which was bacteriostatic to some microbes in a dilution of 1:100 million.

This field is a very promising one, but the final result awaits the discovery by the chemists of the structure of these antibacterial products manufactured in the growth of moulds and bacteria.

Lastly, I would like to draw your attention to the combined use of immunological and chemotherapeutic measures. The sulphonamide drugs are essentially bacteriostatic, i.e. their actual bactericidal powers are small as compared with their power of inhibiting the growth of sensitive bacteria. The final destruction of the bacteria has to be accomplished by the natural defences of the body, and it follows that the more effective are these defences the more effective will the result of sulphonamide treatment appear.

Of course, if the organism is extremely sensitive to the drug nothing else will be necessary, as normally the body is capable of killing off considerable numbers of the bacteria which usually infect wounds, but if the infecting organism is only moderately sensitive then an increase of the immunity may just turn the scale. In any case there is nothing to lose by increasing the immunity, and there may be considerable gain.

The immunity may be increased passively by serum or actively by vaccines. I have demonstrated *in vitro* the synergic effect of serum and M & B 693 in connexion with pneumococcus (1938), and Colebrook (1940) has shown the same thing with hæmolytic streptococci. Henderson and Gorer (1940) have demonstrated the great advantage of the combination of serum and M & B 693 in experimental infections of mice with *Vibrion septique*. But there is no effective serum available for the common wound infections (other than gas gangrene), and I would suggest that vaccines might be used in many of these, in association with sulphonamide drugs.

Fig. 3 illustrates the great difference which a very small degree of immunity conferred by a single dose of vaccine may have on the result of sulphonamide treatment of experimentally infected animals.

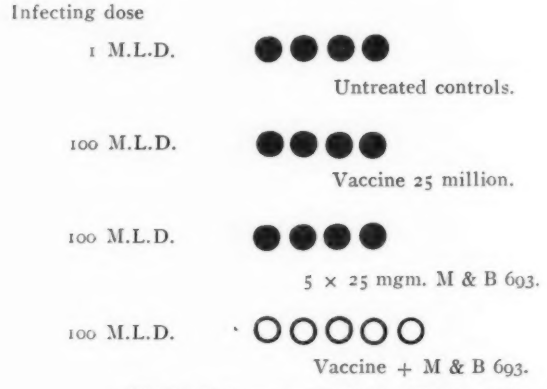

FIG. 3.—Synergic action of pneumococcal vaccine and M & B 693. (Adapted from Maclean, Rogers, and Fleming.)

Mice had a single dose of pneumococcus vaccine. After six days they were infected with virulent pneumococci, and some of them were treated with M & B 693. Those not undergoing sulphonamide treatment all died, showing that the increase of immunity conferred by the vaccine was very little. Unvaccinated mice treated with M & B 693 all died, but the vaccinated mice treated with the same dose of M & B 693 all survived, showing that even the small increase in immunity conferred by the vaccine was sufficient to turn the scale.

Immunity may be increased by non-specific methods, and I would like to see tried a combination of intravenous injection of hypertonic salt and the sulphonamides. The intravenous administration of 20 c.c. of 10% salt solution increases considerably the antibacterial power of the blood to staphylococcus and streptococcus (Fleming, 1926), and this increase lasts for some twelve hours. These injections can be repeated with the same effects. It may well be, therefore, that hypertonic saline injections and sulphonamide would be a very successful combination.

The method of increasing immunity will vary in different cases, but it seems to be quite clear that in principle immunotherapy and chemotherapy can advantageously be combined.

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Dr. Frank Hawking drew attention to the possible use of sulphonamide compounds in preventing gas gangrene. Experimental wounds had been made in guinea-pigs and infected with 10,000 lethal doses of *Cl. welchii* or *Cl. septique*. Insertion of sulphonamide compounds at the same time as the infection saved up to 75% of the animals. Sulphathiazole was the most effective compound, sulphapyridine was moderately effective, sulphanilamide was good against *Cl. welchii* but had no action against *Cl. septique*. Since sulphathiazole is expensive, it was recommended that a mixture of equal parts of sulphanilamide and sulphathiazole should be used; in experimental wounds this was almost as effective as pure sulphathiazole. None of the compounds had much action against *Cl. œdematiens*. In clinical practice, the sulphonamide compound should be reinforced by the prophylactic injection of antitoxin. When treatment was delayed for two hours the results were much poorer; when delayed six hours, all the animals died. Therefore treatment should be applied as early as possible. Oral treatment was less efficacious than local treatment.

Dr. Hawking went on to say that a number of casualties have now been treated with sulphanilamide or sulphathiazole (5 grm. inserted into the wound) and have done very well. The blood concentration is always low; usually less than 1 mgm. per 100 c.c.

In the guinea-pig wounds, sulphanilamide produces a high concentration (about 1,000 mgm. per 100 c.c.) but is all gone within twenty-four hours; sulphapyridine persists for seven to ten days but the concentration is only 40 mgm. per 100 c.c.; sulphathiazole persists for four to five days and the concentration is about 100 mgm. per 100 c.c. Sulphanilamide travels quickly from one end of a wound to the other—sulphathiazole fairly quickly, but sulphapyridine travels slowly, and the concentration at the far end is never high.

Experiments were made in the rat on the diffusion of these compounds across the abdominal wall (which is 2-3 mm. thick) from within outwards. If the tissue (abdominal wall) was dead, sulphanilamide passed through fairly well and after twenty-four hours it produced a fairly high concentration (26 mgm. per 100 c.c.) on the outside. If the tissue was alive, however, with an active circulation, the concentration on the outside was never any greater than it was in the body as a whole. Presumably, when the compound begins to diffuse through living tissue, it soon meets a blood capillary and it is swept away into the general circulation. Therefore if a sulphonamide compound is placed in the cavity of a wound, it will pass down into the crevices, and it will slowly diffuse into pieces of dead tissue; but the concentration which it produces in adjacent *living* tissue will be no higher than that of the body as a whole. In order to reach this living tissue, the local application should be supplemented by oral administration.

Finally Dr. Hawking referred to previous statements that pus would inhibit the bacteriostatic action exerted by sulphanilamide upon bacteria *in vitro*. Nevertheless he had treated several wounds containing thick pus with the insertion of sulphathiazole and had found that the pus often became sterile.

Dr. C. A. Green[1] said that there were few reports of the action of therapy on antibody production which was the part of that mechanism capable of quantitative estimation, although there were associated practical considerations, such as the possible sequence to be expected when treatment had to be stopped for any reason and when infection was likely to continue.

The antistreptolysin O response to hæmolytic streptococcal infection was used for titrating antibody production in experimental infection when prontosil was tried out in rabbits. The results of the experiments indicated little, if any, interference with antistreptolysin O production in the animals as a result of the simultaneous injection of prontosil. In the first experiment the effect of therapy on the response to streptolysin as culture filtrate was studied. Two rabbits of approximately equal weight were given streptolysin O intravenously. The titre of one animal rose from less than 1 unit per c.c. serum at the beginning to 200 units on the fifteenth day and by the twenty-second day the other animal had responded.

When the titres had remained steady for three weeks, the first rabbit was given prontosil daily, receiving 44 c.c. of the 5% solution in twenty-two days; the other received no prontosil. The animals were given the same course of culture filtrate.

In both animals the titres rose on the sixth day. The first animal reached 250 units, the control 100 units. Therefore there was no indication that prontosil had any effect, nor did it produce *in vivo* any substance capable of neutralizing streptolysin O.

In the second experiment the effect of prontosil therapy on the antistreptolysin O response in experimental infection by hæmolytic streptococci was studied.

Four rabbits of approximately equal weight gave A.S.O titration of less than 1 unit per c.c. serum. The first pair had daily injections of 2 c.c. prontosil II (5% solution) for twenty-three days. After seventy-two hours' therapy, hæmolytic streptococci were implanted subcutaneously. The two control animals had similar foci but received no prontosil.

One control animal died on the fourth morning of hæmolytic streptococcal septicæmia. The second control animal recovered.

The curves of the first pair of rabbits differed considerably and illustrated the variation in individual response following identical dosage.

The results indicated that prontosil did not delay the formation of A.S.O nor did it limit the production of antibody.

In part two of this experiment agar foci were again implanted. The results after forty-two days indicated (1) that quantitative variations in reaction are not definite evidence of therapeutic interference, (2) that there was no interference with A.S.O production as a consequence of prontosil therapy, (3) the greatest loss of weight in the animals was associated with the use of prontosil, (4) neither prontosil II nor any *in vivo* derivative from prontosil II had any neutralizing action on streptolysin O.

Major A. E. Francis said that during the past four months he had been collecting the results of treating superficial wounds locally by the insufflation of sulphanilamide powder.

The series consisted so far of 47 cases with 77 wounds infected with hæmolytic streptococci. The group distribution of the streptococci was: Group A, 62 wounds; Groups C. D and G, 3 wounds each; undetermined for various reasons, 6 wounds.

In 20 cases of Group A infections, with 31 wounds, the streptococci disappeared with local therapy only. In three cases with eight wounds sulphanilamide had been given orally as well as locally, and these also remained free until healed. One case, unsuitable for local therapy (compound fracture of the mandible) remained free after oral therapy only. In all, 24 cases with 40 wounds were permanently freed of Group A streptococci.

In 11 further cases with Group A infections in 22 wounds originally, 15 wounds became reinfected or resisted treatment. Two cases (two wounds) were infected with sulphanilamide-resistant strains as shown by *in vitro* tests. One case had a pocket of pus under

[1] Abstract only. Paper to be published in full with graphs in *Journal of Pathology and Bacteriology*.

the scalp which was not drained freely. One case produced one colony of *Strep. pyogenes* in each of two successive swabs after remaining negative for three weeks. In three other cases the infecting streptococcus reappeared after operations, and four cases returned from leave with reinfected wounds. In one of these the streptococcus was of different type, in two of the same type as before, while in the fourth Dr. Griffith was unable to type either strain, owing to the fact that they were persistently granular in culture.

The two cases with three wounds infected with Group C streptococci responded satisfactorily, one to local sulphanilamide only, the other to combined local and oral therapy. In two cases of Group D infections with three wounds, the organisms resisted local therapy, and in three cases originally infected with Group A streptococci, Group D streptococci had later appeared in the wounds during treatment, and had resisted further treatment. Three wounds were originally infected with Group G streptococci. In one of these the organisms disappeared with local treatment only, the second was freed by combined local and oral therapy (the oral therapy was for a co-existing Group A otitis media), and one compound fracture of the mandible was treated orally only.

In applying the powder it had been found that the presence of much exudate, pus, sloughs or deep crevices and pockets prevented wounds from being freed of hæmolytic streptococci by the local application of sulphanilamide. The powder should be applied directly to the wound, and not over tulle gras or other dressings. The co-operation of the clinical staff was necessary to ensure correct application. Sometimes the wounds might be exposed for inspection by the surgeon and during the time of exposure a film of dried exudate formed over the surface. The powder, of course, could not act on a dry wound. Again it was found that sulphanilamide powder had been applied and eusol put on top resulting in the formation of a yellow product which was inactive. It was essential to place moist saline gauze over the wound, which should be covered with a layer of jaconet to retain moisture.

In order to overcome the difficulty of ensuring that the sulphanilamide was applied in a moist form, applications of pastes were being tried.

Professor A. A. Miles had pointed out that streptococci and other bacteria infecting a wound might be recovered from the skin around the wound after they had disappeared from the wound itself. It had been possible to confirm this in a few instances. It was therefore necessary to treat the surrounding skin with an antiseptic, and a trial was being made of dettol cream for this purpose.

The rather macerated appearance which the skin assumed owing to the continued moisture could be remedied by merely leaving off the jaconet for a day or two when the normal appearance would be restored.

It was difficult to judge how soon after the hæmolytic streptococci had disappeared a wound might be safe for grafting. If the number of streptococci was considerably reduced, they might not be recovered in culture, and therefore he had recently adopted the procedure of planting the swabs on blood-agar plates containing 1:500,000 gentian violet (Garrod, 1933). Hæmolytic streptococci had frequently been isolated from these plates when cultures on plain blood-agar plates were negative, particularly if many staphylococci or diphtheroids were present.

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Dr. K. Wallersteiner pointed out that the clinical treatment of wounds was more an empirical than a specific test of chemotherapeutic efficiency. In his own investigations he had employed tissue culture methods in various modifications that could be dealt with statistically to determine the effect of various chemotherapeutic agents on the growth of fibroblasts. Such methods could be applied to biopsy material from the floor of granulating ulcers and wounds. Antiseptics containing zinc or inorganic halogens generally killed off the fibroblasts more rapidly than they killed the infecting organisms. A few experiments had been made on the rate of healing of artificial wounds in rats and rabbits by measuring the percentage change in the diameter of the wound under the influence of various substances. This method he did not consider as satisfactory as

the statistical investigation of tissue culture material. Sulphanyl flavine showed a low toxicity towards fibroblasts and epithelium and was soluble in glycerides and should prove of value clinically. Prontosil was also of low toxicity and increased the rate of granulation and fibrosis. Various derivatives of -1-amino-8-naphthol-3·6 disulphonic acid, a common constituent of various azo and tetrazo dyes, showed specific stimulation of fibroblast growth and also a specific affinity for fibroblasts and to this type of compound active antiseptic groups may be linked to obtain a compound with doubly useful properties. Various other complex derivatives including sulphanilamide naphthalene-sulphonic acid urea derivatives showed similar properties.

JOINT DISCUSSION No. 3

Sections of Medicine and Ophthalmology

Chairman—SIR MAURICE CASSIDY, K.C.V.O., M.D.

(President of the Section of Medicine)

[*February* 25, 1941]

DISCUSSION ON IRIDOCYCLITIS

Dr. W. D. Wykeham Brooks: The term iridocyclitis covers a variety of inflammatory disorders. The following ætiological classification of iridocyclitis shown in the table is based upon that recently published by Duke-Elder (1940).

TABLE.

(1) *Exogenous infections:*
- (*a*) Trauma or wound infection.
- (*b*) Intra-ocular parasites.
- (*c*) Chemical, animal or vegetable poisons.

(2) *Secondary infections:*
- (*a*) By direct continuity from other ocular inflammation.
- (*b*) Toxic or allergic inflammation secondary to unusual ocular products, e.g. neoplasm, detached retina, &c.
- (*c*) Traumatic iridocyclitis other than that of group (1).
- (*d*) Sympathetic ophthalmitis.
- (*e*) Neurogenic uveitis, e.g. herpes zoster.

(3) *Endogenous infections:*
- (*a*) Inflammations associated with specific fevers, e.g. measles, dysentery, influenza or meningitis.
- (*b*) Inflammations associated with metabolic diseases, e.g. diabetes, gout.
- (*c*) Inflammations associated with diseases of the skin, e.g. alopecia, urticaria, erysipelas.
- (*d*) Inflammations due to organismal metastases, in pyæmia, tuberculosis, syphilis, leprosy.
- (*e*) Inflammations of unknown ætiology due possibly to organismal or toxic or allergic factors.

Within the last sub-group in the classification are incorporated perhaps a majority of all cases of iridocyclitis; their ætiology is a matter of dispute: in general the lesion is of the chronic and recurrent type.

ÆTIOLOGY OF CHRONIC RECURRENT IRIDOCYCLITIS

Sixty years ago a majority of these cases would probably have been ascribed to syphilis, a minority to tuberculosis, while a considerable proportion of the remainder would have been thought to be due to the gouty or rheumatic diathesis.

The first quarter of this century marked the rise in England and in U.S.A. of the concept that focal sepsis was a dominant factor in the ætiology of this disease (Goulden, 1914; Irons and Brown, 1916), while over the same period of time on the Continent there developed an equally strong view as to the importance of the part played by tuberculosis (Hessberg, 1918; Gilbert, 1930). In both hypotheses a transient bacteriæmia is assumed whereby the organism concerned reaches the uveal tract, and both hypotheses gained support when such bacteriæmias were shown to occur (Dental infections, Okell and Elliott, 1935; Tuberculosis, Lowenstein, 1931; Urbanek, 1932; Meller, 1934).

It is usually possible to demonstrate the existence of one and often of several foci of infection in any individual; the results of skin sensitivity tests and autopsy investigation have shown that the great majority of adults have been infected with tubercle bacilli, and it is known that once this has happened subsequent hæmatogenous spread of the disease is a persistent possibility. Immunotherapy based on either theory has only occasionally been sufficiently successful to be of help to the theory on which it is based. The major objection, however, to both comes from histological examination of the uveal tract in these cases, for it has scarcely ever been possible to identify any organism within the lesions, and the inflammatory reaction of the tissue is usually non-specific. Both these findings are in marked contra-distinction to the results of pathological examination of the eye in cases of iridocyclitis in other groups of our classification.

In recent years it has been held that cases of chronic recurrent iridocyclitis are due to the excitation of a local allergic reaction by bacterial products liberated from a focus of infection in a relatively immune but allergic patient. Such a focus might be pyogenic, in the teeth, tonsils, sinuses, gastro-intestinal or genito-urinary tracts, or it might be tuberculous within a mediastinal or mesenteric gland. On such a hypothesis the difficulty of the frequent coincidence of multiple foci of infection has been met by the experimental demonstration that multiple sensitization of the eye can be obtained by the injection of different allergens, either bacterial or protein (Brown, 1935). Some authorities (Duke-Elder, 1940) go further and suggest that a combined sensitization to a tuberculous and pyogenic focus or foci may account for some of these cases. The rarity with which active tuberculosis is complicated by active pyogenic infections is, however, well known, and recent work (Houghton, 1941) has in fact shown that in general no relationship exists between sensitivity to tuberculin and streptococcal endotoxin. Such an assumption is therefore unlikely to be true. Further research is necessary before this theory can be regarded as other than rather vague.

The following scheme will usually provide the necessary data for assessing a case.

Scheme of Investigation

(1) A complete history and clinical examination.

(2) Radiological examination of the chest, and in some cases of other areas.

(3) Examination of the blood in order to exclude syphilis and gonorrhœa, to assess the presence and degree of anæmia, and to ascertain the condition of the white cells. The sedimentation rate and the Von Bonsdorff index may also be of value.

(4) Bacteriological investigation with a view to ascertaining the existence and nature of the infection in suspected foci of sepsis. The examination of sputum and excreta for tubercle bacilli.

(5) A Mantoux reaction should be obtained in every case, starting at a considerable dilution, the strength of the injected tuberculin being increased until either a positive reaction is obtained or a dilution of 1:100 attained. Skin sensitivity tests to other allergens may be desirable.

(6) Biopsy with histological, bacteriological, and biological tests of glandular or other tissue.

Clinical Types of Chronic Recurrent Iridocyclitis

In this disease there exists considerable variety in the clinical manifestations and in the results of investigation. In general, four main types may be recognized.

Type 1.—Approximately 40% of all these cases will present no clinical or radiological evidence of disease other than that immediately dependent on the ocular lesion. If

the patient be an adult, the Mantoux reaction will as a rule be positive at a considerable dilution, whilst some focal sepsis may be found.

Type 2.—About 25% of the cases will give evidence of active or arrested pulmonary tuberculosis. Those with arrested disease will exhibit no symptoms referable to it, and the lesions will as a rule only be demonstrable by radiology of the chest. This may show calcified or fibroid scars which in most cases will mark the place where either a primary infection or a secondary hæmatogenous spread within the lungs has been overcome. In these patients the Mantoux reaction is as a rule positive, while focal sepsis may or may not be present.

Patients with active pulmonary tuberculosis present the typical symptoms and signs of their disease in addition to those derived from the ocular lesions. Radiology will usually show that the disease is more extensive than the physical signs would suggest; the lesions tend to be bilateral and to be suggestive of hæmatogenous rather than bronchogenous dissemination. Excavation is on the whole uncommon, and many examinations of the sputum may be necessary before tubercle bacilli can be demonstrated. It is noteworthy that while these patients tend to follow the irregular and on the whole deteriorating course of the disease, there is usually no direct relationship between the course of the pulmonary and the ocular disease. Furthermore, other hæmatogenous tuberculous lesions may frequently co-exist, and thus, for example, renal or bone tuberculosis may contribute to the symptoms and signs exhibited. The Mantoux reaction is as a rule positive except in the terminal phases, while focal sepsis is usually conspicuously absent.

Type 3.—A small proportion of cases, about 5% in all, may give clinical evidence of tuberculous lymphadenitis, either apparently healed or manifestly active. Thus a variety of toxic manifestations, including loss of weight, irregular pyrexia, local evidence of enlarged glands in the neck or elsewhere may be found. Within this group occasionally there will appear cases of Bazin's disease. Radiological investigation may identify these cases where glandular involvement within the abdomen or thorax does not permit clinical recognition. Thus calcification may be shown in the affected site, while if really gross enlargement has occurred, demonstration in this way is possible in the cases of intrathoracic lymphadenopathy. Physical signs are as a rule uncertain except when the glands are subcutaneous. A biopsy in many cases should settle the diagnosis and will often permit isolation of tubercle bacilli. The Mantoux reaction is found usually to be positive in high dilutions, while focal sepsis may co-exist especially if the glandular lesions are quiescent.

Type 4.—In about 30% of the cases the ocular manifestations are dramatic but incidental features in the course of a generalized systemic infection which would be classified by some authorities as chronic miliary tuberculosis. Within this group are incorporated examples which are undoubtedly of that disease, but in addition, for example, cases are included of uveo-parotitis and Boeck's sarcoid concerning which the ætiology is in dispute. Abundant similarities, however, exist clinically and justify considering these cases as of one group. Irregular recurrent pyrexia, anorexia, loss of weight, sweating, myalgia, amenorrhœa, and commonly a moderately severe microcytic hypochromic anæmia all provide evidence of severe infection. Generalized lymphadenopathy is common, splenomegaly not infrequent, and cutaneous manifestations such as those of Boeck's sarcoid, or frank tuberculides may be encountered. In a small proportion of cases cystoid changes in the small bones of the hands and feet are to be found. In examples of uveo-parotitis, the enlargement of parotid and other salivary glands may be accompanied by transient neurological manifestations such as a 7th nerve palsy. Palatal paresis, ptosis, and diplopia occur, but are rare. Usually the physical signs suggest that the neurological lesion is a peripheral neuritis, although there are a few recorded instances of spastic paraplegia complicating the disease, which would seem to show that the cerebrospinal axis may be involved. The only common neurological lesion, however, is a 7th nerve palsy, and since this is sometimes accompanied by loss of taste, it is probable that the site of the lesion is proximal to the origin of the chorda tympani.

Transient arthralgia with or without effusion may be noticed.

The physical signs in the chest are minimal, though râles may be present, and D'Espine's sign may be positive. Radiological examination, however, frequently discloses the presence of gross mediastinal glandular enlargement, and a fine but not

necessarily symmetrical reticulation more or less superimposed upon nodulation throughout the lungs. It is becoming recognized that these appearances are largely dependent upon pulmonary lymphatic obstruction. The Mantoux reaction is usually negative or only slightly positive in the more concentrated solutions. In this connexion the recent work of Lemming (1940) is of interest, for he was unable to convert such a negative reaction in cases of uveo-parotitis into a positive reaction, by injection of large doses of *Bacillus Calmette Gengou*. The contrast in the behaviour of these patients in this respect to that of individuals previously uninfected with tubercle bacilli is well marked. and may indicate that in this disease they are already desensitized to a high degree by their own lesions. Lemming also showed that the lymphadenitis caused by the B. C. G. injections was typically tuberculous in the previously uninfected group, but was sarcoid in type in the cases of uveo-parotitis. Patients with recurrent chronic iridocyclitis in this group as a rule show little or no evidence of focal sepsis. Biopsy of a gland will show either tuberculous or sarcoid changes, while, if death occurs, post-mortem commonly reveals miliary tuberculosis.

Treatment

Brooks, Juler and Williams (1940) found that deep X-ray therapy to the mediastinal glands in cases where these glands were obviously enlarged, might be of value in preventing further relapses in the ocular lesions. This method of treatment is worthy of further trial. The use of ultra-violet light should be restricted to cases in which no evidence whatever of co-existent pulmonary tuberculosis is found.

Long-continued rest is far more likely to be productive of permanent results than any other therapeutic measure. Whether any evidence of tuberculosis either pulmonary or generalized is found or not the local ocular lesion is most likely to become permanently quiescent if the patient is rested to a degree comparable to the absolute rest required by cases of active pulmonary tuberculosis. The duration of the rest period will vary in individual cases, and will depend upon the degree of activity as indicated within the eye, or by toxæmia, or by the information afforded by such investigations as the sedimentation rate. When the local or general lesions present evidence of quiescence, sanatorium treatment is highly important. Cases with co-existent active pulmonary tuberculosis may, in addition to the above, require collapse therapy.

In those cases where no evidence of pulmonary tuberculosis is found, the eradication of foci of infection and the use of vaccines may be of value.

It seems unnecessary as well as ineffective to use tuberculin in cases of chronic miliary tuberculosis or uveo-parotitis. When active pulmonary tuberculosis is present the danger of provoking dangerous reactions within the chest or eye outweighs its possible value. In the other types if it is used at all it should be given with a view to desensitizing the patient rather than to produce a focal reaction, and this will imply the use of very small graduated doses while carefully following the sensitivity of the patient by means of the Mantoux reaction. Isolated accessible glandular tuberculosis may require surgical intervention.

Prognosis

The local ocular prognosis I shall leave to my ophthalmic colleagues. As far as the general health of these patients is concerned, only the last three types need be considered.

In cases of Type 2 the prognosis is that of the pulmonary tuberculosis they present. Cases of glandular tuberculosis in Type 3 as a rule do well in regard to their general health. Rarely, in both instances, fatal miliary tuberculosis may develop.

A proportion of the cases in Type 4 make a complete recovery, and it is impossible to foretell which individual will in fact proceed to healing all of the lesions. Nor do we know when or why a catastrophic acute miliary tuberculosis may supervene. We are equally ignorant of the reasons why other cases die after a more or less chronic illness of some months or years duration. However, the persistence of high irregular pyrexia, which may show inversion, and an alteration for the worse in the blood picture, together with progressive advance in the radiological appearances within the chest, make the possibility of recovery more and more remote.

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Colonel F. Juler: *Ætiology.*—Out of 87 private cases of iridocyclitis which I have analysed, the probable factors were as follows: Gonorrhœa 21, focal sepsis 25, tuberculosis 18, syphilis 5, rheumatoid arthritis 4, influenza and nasal catarrh 4, diabetes 1, herpes ophthalmicus 1. In some of these a double factor was thought possible and in 13 cases no probable cause was discovered.

In addition, the following causes are recognized: Leprosy, spondylitis deformans, and a group including uveo-parotitis, sarcoidosis, and some forms of reticulosis with a possible relationship to tuberculosis.

Rheumatoid arthritis.—This is a definite though small group occurring in elderly women, with a moderate degree of arthritic change. Three of my patients were 55, 61, and 70 years of age respectively, at the onset of the iritis. The fourth would only admit to 46 but was certainly older. In three cases the iritis was subacute and yielded to treatment, in the fourth the condition had insidiously led to blindness of the affected eye.

Catarrh of the upper respiratory passages.—The four cases under this heading had acute attacks during convalescence from influenza, bronchitis, and nasal catarrh. The attacks subsided reasonably well, and as far as I am aware were not followed by relapses. It seems reasonable, therefore, to associate the respiratory infection with the iritis.

Gonorrhœa.—Iritis in the female from this cause is unusual. Among 42 private cases of iritis in the female I had only 2 in which gonorrhœa was suspected and even in these there was considerable doubt of its rôle. In the male, on the other hand, out of 45 cases of iritis, 19 had a definite history of gonorrhœa. It is interesting too that of my first 20 cases in the male (up to the year 1927) 55% had this cause, but of my last 27 cases in the male only 29·6% were associated with a history of Neisserian infection. It is my impression, which is borne out by these figures, that typical acute gonococcal iritis is less common than it was, and that this decrease is occurring in hospital as well as in private practice. Presumably this is due to the better education of the laity and to their general awareness of the disease, whilst in future the number should be smaller on account of the beneficial effect of sulphapyridine (M & B 693) in the treatment of the original urethritis.

Another point brought out in this analysis is the long latent period between the attacks of iritis and the urethral infection. In several of my cases the attack for which I was consulted was not the first one, but the average latent period between the first urethral attack and the iritic outbreak was as much as 14 years. The shortest one that I have known was of some five or six weeks, but patients' statements are often misleading, and one gentleman admitted to eight separate urethral infections.

In cases of doubtful ætiology the complement-fixation test and the prostatic massage test may be of value. In doubtful cases, too, there may be a second ætiological factor.

Therapy.—I am not certain that the administration of the sulphanilamides clears up attacks of gonococcal iritis. The drugs have been used in my clinic for many types of iridocyclitis and nearly all of them have done well, but I am yet uncertain. For instance the patient (W. M.) for a second attack of iritis received four days' full treatment with sulphathiazole (2 tablets four times daily). On the fifth day iritis developed

in the other eye and ran a sharp but short course, almost identical with that taken by the first eye. His was definitely a gonococcal case.

Focal sepsis.—The French writers Lagrange and Goulesque have recently supported the factor of focal sepsis in an article (*Bull. et mém. Soc. franç. d'opht.*, 1939, 51, 334) which brings tissue allergy into the picture of this and other groups of iridocyclitis. They explain the frequent involvement of this region by the large amount of reticulo-endothelial tissue found in its structure. Whether such a theory is finally accepted or not, I do not think that there are many ophthalmologists in this country who are not convinced that occasionally at any rate focal sepsis is a definite ætiological factor. The question of eradication is one which requires considerable acumen and clinical balance for the best ultimate good to the patient. There is no doubt but that to some persons the removal of a number of teeth is an upset, and I have known several cases in which severe hæmorrhage has followed intra-nasal operations and has caused a considerable period of ill-health. It may be better to risk relapses than to insist on overmuch surgery.

On the whole the most typical cases will be those of one or more attacks of subacute severity, tending to affect the iris with formation of adhesions rather than the ciliary body with its more serious consequences.

Syphilis.—There is a tendency to omit syphilis as an ætiological factor except in the inherited disease, when the iritis is most commonly associated with interstitial keratitis. It is well, however, to bear it in mind, as a recent case has shown:

H. J., aged 40, came with a large solid-looking mass of exudate in his right anterior chamber underneath a considerable amount of central corneal opacity. The pupil was bound down and vision reduced to perception of hand movements. His wife was found to be attending the V.D. clinic and his Wassermann reaction was positive. In addition a lumbar puncture showed evidence of meningo-vascular syphilis, although no clinical signs or symptoms save those in his eye were discovered. After five injections of novarsenobillon (0·45 grm.) and six injections of bismuth (0·2 grm.), the eye became free from inflammation, the exudate was reduced to a small central opacity in the dilated pupil, and the vision had recovered to $\frac{6}{9}$.

Typical syphilitic iritis of the secondary stage has long been known to be characterized by the appearance of vascular nodular swellings close to the pupillary margin. This condition is infrequently met with, but reacts well to mercury and the arsenical preparations.

In severe cases of plastic iridocyclitis, and especially if the choroid is involved, syphilis should be suspected. The rapid response of syphilitic cases to neo-arsphenamine and bismuth is very striking, and, as both eyes are often affected, the result may be gratifying. This is in striking contrast to the complete inefficacy of any general treatment in interstitial keratitis.

Tuberculosis and ? allied conditions.—There are certain cases in which the probability of a tuberculous ætiology can be suspected from the clinical appearances, especially if the case is seen fairly early in its course. Most of us are now agreed that the appearance of "mutton fat K.P." is very suggestive. In such cases the prognosis must always be grave. The disease tends to start in early adult life and usually affects both eyes. Slight at first, exacerbations of increasing severity occur every few months with gradual deterioration of vision. Later the pupil becomes bound down, the typical deposits may not be present, but the ciliary body becomes atrophic, and after a period of years the eye may shrink. It is in such cases as these that I desire to endorse Dr. Brooks' remarks on the most suitable line of treatment, namely the sanatorium régime with a preliminary period of rest in bed, a full diet with a high vitamin content, and later on regulated exercise.

Dr. Brooks has spoken of the use of tuberculin, and from the progress of my cases, I incline to omit its use in my clinic. So many in the series of cases of which he has spoken have continued or accelerated on the downward way soon after a course of tuberculin, that I support his arguments against its use.

I have come to the same opinion with regard to ultra-violet light. From ultra-violet applications to the eye itself for iritis I believe that nothing but harm can ensue, whilst applications of these rays to the body generally should be very sparingly used if at all.

There are, of course, other types of tuberculous iridocyclitis, for instance, profuse caseating exudations forming masses in the anterior chamber. A more definite tuberculoma is sometimes found with a localized tumour formation in the periphery. Such

tumours may resolve quickly, but tend to result in degeneration of the vitreous and cataract, presumably from involvement of the ciliary body.

An interesting appearance is that of gelatinous-like nodules near the pupillary margin, which are said to be seen not only in tuberculosis, but also in syphilis, in sympathetic ophthalmia, and in leprosy. This is sometimes spoken of as Doyne's guttate iritis or Koeppe's nodules. An example is given in fig. 1, which illustrates the appearances in the right eye of a woman (W. H.), aged 37 years, of which the vision had been slightly blurred for a few weeks. It shows that in this case the nodules seem to be of the iris stroma, for it can be seen how the posterior layers have lost their pigment in similar places and have become translucent. The nodules are, however, usually held to be deposits on the surface of the iris stroma. Beyond a few small deposits on the back of the cornea and an "aqueous flare" the eye was otherwise healthy. Her left eye had been failing for six years and was excised. Microscopical examination showed no evidence of tuberculosis, there being a general infiltration of the iris and ciliary body with plasma cells, and several localized nodules of lymphocytes in both these structures. The woman showed no evidence of constitutional disease, and the radiological report of the chest was negative.

Local treatment.—Subconjunctival injections of mydricaine have now proved their value for occasional use at the start or during the course of treatment, although atropine should first be given a fair trial when time permits. The injection does definitely upset a certain proportion of patients, possibly through the adrenalin constituent. I have read that it may be used without reaction in patients sensitive to atropine, but this is certainly not true in many cases.

My experience of Schieck's treatment of recurring cyclitis by injection of the patient's own blood into his anterior chamber is limited to two cases, and I am not satisfied that it had any beneficial effect.

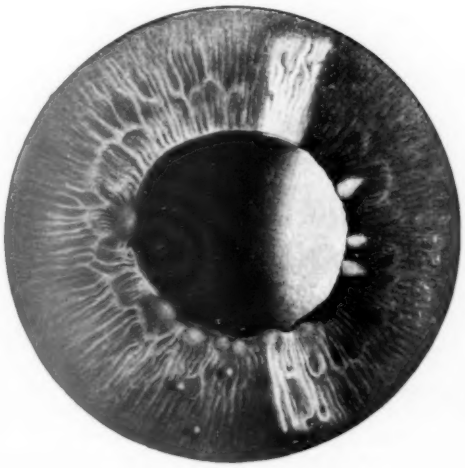

FIG. 1.

A number of Koeppe's nodules are present along the pupillary margin of the iris, and translucent areas are shown on the nasal border. A few posterior corneal deposits and an aqueous flare were seen. (Drawing by Messrs. Hamblin Ltd.)

The treatment of associated increase of tension is often difficult. Straight cases of iris bombé do well by quadruple puncture or iridectomy, but the complication may be an awkward one in tuberculous uveitis. In this disease the tendency is often for a variation of tension, severe cases passing over into hypotony in the later stages. On the whole the system is one of serious import in prognosis, and in its treatment the

eye should be submitted to the minimum of operative trauma. Paracentesis of the anterior chamber may be repeated on several occasions, and if this fails iridectomy may be imperative. Corneo-scleral trephining is only likely to be successful in cases with little congestion. Theoretically cyclodialysis might be of value, if its mode of action is due to the diminution of its blood supply from the ciliary body; I have, however, no experience of its effect in such cases of secondary glaucoma.

Dr. R. D. Lawrence said he had seen a dozen or more cases of this conditions in diabetics, but it did not seem so widespread among them as other eye diseases. The noticeable feature in untreated cases was the increased vascularity, shown by the high proportion in which ectropion occurred. He showed an illustration of a case first published in the *British Journal of Ophthalmology*, 1936, **20**, 198, which was of interest because it presented the most unusual features of vascularization in iritis or iridocyclitis. Not only was the iris covered with large vessels, but these extended on to the front and back of the cornea. The patient had had diabetes for twelve years and had paid no attention to it until the onset of this eye trouble, which began with some retinal hæmorrhages centrally, not peripherally. By the time the iris had become involved the diabetes was being treated energetically, but the process spread and there was complete loss of vision and a glaucomatous eye in about six months. Subsequently there was a vast increase of large vessels in front of the iris and also an engorgement of the vessels on both the front and back of the cornea, all of which disappeared later.

Mr. F. A. Williamson-Noble: The ætiology of iridocyclitis is baffling. There may be two possible solutions: (1) that the lesion is allergic: (2) that it is due to direct implantation of organisms. A third possibility, which is a combination of these two, has been admirably described by Duke-Elder ("Textbook of Ophthalmology", 1940, **3**, 2143).

"An infective element which ordinarily is a common and minor event occurring intermittently in apparently healthy persons without mishap and giving rise to no systemic clinical evidences, in the presence of tissue allergy, at once assumes unwarranted importance, the primary ætiological factor being the condition of sensitization of the local tissue rather than the virulence of the causative infective organism."

Various explanations of the mechanism by which this occurs have been put forward, of which the most notable perhaps is Rosenberg's theory of partial oxygen tension. According to this, the oxygen tension is different in different parts of the body, and organisms after a lapse of time become conditioned, say, to the tension found in the uvea, and hereafter grow only when exposed to this tension, and therefore only in the tissue where such a condition occurs. This theory does not seem to have stood the test of further experimental work, and is not much heard of nowadays.

One would like to know how organisms previously harmless to the eye can become the very reverse. Had it not been for the war, I was hoping to carry out some experimental work on this subject, but as this has proved impossible, I shall present a theory in which are many lacunæ waiting to be filled by experimental work. A good starting point is provided by Waller's work on atropine irritation (*Trans. Ophth. Soc.*, 1934, **54**, 96). This observer found that if atropine solution were injected into the arm of a patient with atropine irritation, no reaction followed, but that if atropine mixed with tears from healthy patients were employed, a marked skin reaction ensued. Such a finding seemed to indicate that in some way or other the protein of the tears and the alkaloid atropine had managed to form a compound, toxic to the patient's skin.

The next observation which shows that something of a similar nature can occur was provided by Burky (*J. Allergy*, 1934, **5**, 466) who, in immunizing a series of rabbits against a staphylococcus, found that he had made them sensitive to the broth in which the organisms had been grown. This work was elaborated by him, and by the synergic action of staphylotoxin he succeeded in sensitizing rabbits to various other substances, among them lens protein and homologous muscle tissue. Lucic (*Arch. Ophth.*, 1939, **22**, 359) used the same method with uveal tissue employing three series of rabbits. To the first group, he gave intracutaneous inoculations four times at weekly intervals of a mixture of uveal tissue and the exotoxin of a staphylococcus which was lethal to rabbits. To the second group, he gave inoculations of uveal tissue only, and to the third, inoculations of uveal tissue and killed *B. subtilis*, an organism which is non-toxic to rabbits. The last two groups gave entirely negative skin reactions on subsequent injection of uveal pig-

ment, but six out of the twenty-two animals comprising the first group, i.e. those which had a mixture of staphylotoxin and uveal pigment, showed histological skin reactions characteristic of hypersensitivity. A disappointing feature of the experiments is that intraocular injection of uveal pigment in three of the hypersensitive animals, combined in one of them with a ragged iridectomy in the fellow eye, failed to produce a histological picture greatly different from that in control animals similarly treated.

The experiments seem to show, however, that given time, a toxic organism can produce hypersensitiveness to tissues which in the ordinary way were harmless. The time element is probably important, and serves to explain the lag which occurs in, say, gonococcal iritis where many years may elapse between the initial urethritis and the intraocular inflammation. The same is probably true of the streptococci in dental apical abscesses.

At this stage it is not safe to assume that the iritis is merely due to the presence of uveal tissue to which its owner has become hypersensitive. It seems more likely that something happens, analogous to what Waller found in atropine irritation, namely that some new compound is formed by the interaction of the toxin and the local tissues, and that it is this which is responsible for firing off the attack. When we remember that the proteins both of the lens and the uveal tract are organ specific and not species specific, it serves to explain the elective localization of the lesions to the eyes in such cases. In other words the gonococci, streptococci, or whatever organisms are responsible can circulate harmlessly provided they do not meet with the particular protein with which they can form their noxious compound.

Here is a case which seems to have some bearing on this hypothesis. A boy, J. R. E., was sent to see me in November 1931, at the age of 15½, with a history that three years previously he had had some redness of one eye and that the other became affected later. Since that time he had had attacks off and on, each one lasting for about a month. He had been seen by an ophthalmic surgeon who had found nothing wrong.

On examination, the right eye read $\frac{6}{6}$ partly and the left eye $\frac{6}{6}$ with correction of hypermetropia and astigmatism. The discs, fundi, and fields were normal, but the slit-lamp showed a faint flare in the aqueous, with some bedewing and fine K.P. in each eye. Foci of sepsis were looked for and a vaccine was made from the tonsillar fossæ.

In January 1932 vision of each eye was up to $\frac{6}{5}$ with correction, but K.P. was still present, though there was no aqueous flare, and the same condition of affairs was present in March. On account of this, a small dose of tuberculin was administered, and the eye flushed up next day. Matters went on like this for the whole of 1932, with fairly well-marked K.P. and a trace of vitreous haze.

After this, I did not see J. R. E. again for a period of about six years, during which time he said that his eyes had not troubled him, though I doubt if fine K.P. could really have been absent. In December 1938, however, the vision of each eye had gone down to $\frac{6}{12}$ partly, the K.P. was more profuse, and there were early posterior polar cataracts with definite aqueous flare. He was taken into hospital for examination, but nothing was found beyond a growth of hæmolytic and viridans streptococci in the throat. In view of the apparently positive focal reaction to tuberculin, he was examined both clinically and radiologically for evidence of active tuberculosis, but nothing was found. Even the Mantoux reaction was negative to 1 : 10,000 O.T. though it was positive to 1 : 1,000. Treatment, based on these findings was carried out, but although the aqueous flare diminished, the K.P. remained, so I sent the patient out to Dr. Werdenburg's clinic at Davos, where he remained for some four months, having treatment. In spite of this, however, on his return, J. R. E. still had K.P. in both eyes, and vision was less good owing to increase in the posterior cortical cataracts. These became progressively larger, and in January 1940 I needled the left lens by Ziegler's method, making two converging incisions through its entire thickness. I expected a pretty violent reaction, and kept the patient in a nursing home for ten days in case of complications. Nothing happened, however, so I did not evacuate the lens matter. The eye kept quite white, and within nine weeks had a clear gap in the pupil through which the patient saw $\frac{6}{5}$ partly with a sphere + 13·50. Seven weeks later the eye was doing excellently, and I found to my surprise that the K.P. had disappeared. Encouraged by this I did a Ziegler needling on the right eye with a similar result, except that a little membrane remained which

had to be cut through before a perfectly clear pupil was obtained. When last seen, in November 1940, the vision of each eye with correction for aphakia was $\frac{6}{5}$ the left eye showed no K.P. and the right only faint traces. Vitreous opacities which had been present in the right eye had cleared entirely. What interpretation are we to make of such a case? One thing at any rate seems obvious, that the K.P. was in some way associated with the presence of lens matter.

Deposits on the back of the corneæ had been present for a period of nine years previous to needling and possibly for two or three years previous to this. They disappeared from the left eye after absorption of the lens, but were still present in the right eye, until the lens of this eye was also removed. If the deposits had been due to some allergic reaction due to lens protein, one would have expected a violent intra-ocular reaction when a large quantity of this protein was suddenly liberated. On the other hand how could they be just passive deposits of lens matter such as the lens K.P. which is often seen after cataract operations, when the lens capsule was intact and the lens proteins could not escape except in solution? One explanation, which is perhaps a lame one, is that the curative effect of the liberation of lens matter was analogous to the beneficial effects sometimes produced in cases of chronic iridocyclitis by the injection of blood into the anterior chamber.

Another possibility is that although a large quantity of lens matter is available for solution in the aqueous, only a small amount is taken up at any particular time, the whole lens requiring some two or three months for its disappearance. When it has once gone, the protein with which the circulating toxins or organisms had made their compound was absent, and the bacterial toxin was therefore rendered harmless, so far as the eye was concerned.

Professor A. J. Ballantyne: Our views on the ætiology of this disease are usually very speculative. General medical investigation may find a negative response to all tests, or it may reveal many abnormalities—in teeth, tonsils, gall-bladder, chest, &c.—any one of which might be selected as *the* cause.

The results of treatment directed to the possibly causative lesion may provide a clue to the ætiology, for example, the beneficial results of removal of septic foci. The surgical treatment of so-called focal sepsis has been strongly advocated and strongly condemned. The general rule should be that a lesion which we believe to demand treatment on its own merits, should be dealt with.

It is my own impression that two of the most important causes of chronic relapsing iridocyclitis are *tuberculosis* and *gastro-intestinal intoxication*.

In this connexion I have in mind a number of cases which have been under my observation for periods up to seventeen years or more.

The first of these, which I regard as tubercular in origin, is that of a young man, now in his forties, whom I have followed since 1924. At that time he had a mild paresis of one external rectus, but the eyes were in other respects normal. Eighteen months later the left eye was dim (L.V., corrected; $= \frac{5}{12}$ partly) from a quiet iridocyclitis with K.P., precipitates on the lens surface, vitreous opacities, posterior synechiæ, and grey nodules on the iris border.

He was found to have defective teeth, ethmoiditis with nasal polypus, tubercular gland scars in the neck, physical signs of old tubercle at right apex, &c., with negative sputum, positive v. Pirquet reaction, and negative W.R. There was also excess of urobilin and indican in the urine, believed to indicate protein putrefaction in the bowel and a defect in the detoxicating function of the liver.

Treatment has been directed to all these abnormal conditions; but from the presence of grey nodules on the iris and from the man's general physical condition I have always looked upon him as essentially a tubercular case, and tuberculin in small doses has formed part of his treatment.

During the seventeen years, now one eye, now the other, showed a dimness of vision from increase in the vitreous opacity and K.P., but these attacks have become less frequent and less severe, and even now, for three or four years at a time, the vision remains $\frac{5}{9}$ or better.

A second case, clinically similar, with the addition of "mutton fat" K.P., in a woman of the same age, has been under treatment for seven years, tuberculin being given in

repeated courses in small doses, and for the last three years there has been scarcely any variation in the vision from R. $\frac{5}{12}$, L. $\frac{5}{6}$ the right eye having still a faint flare and some cells in the aqueous.

As bearing on the question of tubercle in these conditions, I should like to refer to the case of a woman in the fifties, first seen four years ago, suffering from a chronic recurring iridocyclitis, with glaucomatous tension (R. 42 mm.Hg; L. 33 mm.Hg). When first seen vision was: R. = less than $\frac{5}{60}$; L. $\frac{5}{60}$. Here also, in addition to K.P. and vitreous opacities, there were grey nodules on the iris. She had been treated with miotics, but without improvement.

Her general condition was poor, but two outstanding facts were, a pronounced cystitis and an eruption of small reddish nodules, mostly on the skin of the face and neck. Local treatment with scopolamine, dionine, and dry heat reduced tension a little but not to normal, and iridectomy was done in both eyes. Tension gradually settled down at about 22 mm.Hg and vision improved to R. = $\frac{5}{36}$, L. $\frac{5}{18}$, but the visual defect was entirely due to the glaucomatous state with cupping and atrophy of the discs, for the media cleared completely. Real improvement in this respect only began when I advised the use of tuberculin in 1939, and I felt justified in attributing the improvement to this treatment, for at the same time there was a rapid and striking disappearance of the skin nodules, which I believe to have been of the nature of a sarcoid and therefore possibly tubercular.

It will be noted that in two of these cases, tubercle was only one of several possible causes, including, in one case, septic teeth, ethmoidal disease, and intestinal intoxication, in the other cystitis; but in some cases of chronic iridocyclitis the state of the bowel seems to be the only factor of importance.

One example of this is a young woman first treated fourteen years ago, again a case of bilateral chronic iridocyclitis with K.P., dusty vitreous opacities, and grey iris nodules. Constipation was marked, and nothing else abnormal was discovered. A thorough regimen directed to this condition gradually brought about a "cure" of the iridocyclitis and for the last twelve years there has been no relapse.

A similar ætiology seemed to be responsible for the condition in a young man of 37, first seen sixteen years ago with almost complete cataract in one eye, minor lens opacities in the other, and K.P., &c., in both. General examination was practically negative although streptococci obtained in culture from the gums and tonsils, and paratyphoid organisms in the fæces, were possibly of importance. Extraction of the cataract was successful, K.P. and vitreous floaters disappeared from the operated eye, and vision with correction was $\frac{6}{6}$ and Jaeger 1; but, three or four years later, tension rose, and was not relieved by Herbert's small flap operation and cyclodialysis, and ultimately vision in the aphakic eye was lost from chronic glaucoma. The second eye has remained in its original condition. Three years ago a gangrenous appendix had to be removed, and it was discovered that there had been marked constipation for some years. His general health improved greatly after this operation, and it may also account for the maintenance of the satisfactory condition of the second eye.

This leads me to refer to the tendency shown by cases of chronic iridocyclitis, whether with or without cataract, to the development of glaucoma. I have had several cases in which there has been such a complete disappearance of K.P. and vitreous opacities that without knowledge of the history one would have described the glaucoma as primary.

Why one case should escape this complication and another suffer from it is difficult to understand; but the ultimate prognosis in case of chronic iridocyclitis depends almost entirely on this factor.

In general it is a mistake to offer a bad prognosis in cases of chronic relapsing iridocyclitis even if it is apparently resistant to treatment. Many of them, under persistent treatment, local and general, can be greatly improved and maintain the improvement over long periods. No doubt when glaucomatous tension does occur, iridectomy or some decompressive operation may prevent or retard visual loss, but I have not always obtained this happy result. It would be a great boon if we could forestall the onset of high tension by some modification of our local treatment or even by early operation, but to achieve this we must be able to differentiate the cases in which rise of intra-ocular pressure is likely to occur. Tonometric control of these chronic relapsing cases certainly seems to be called for.

Dr. W. M. Crofton said that there appeared from that discussion to be a certain amount of difference of opinion as to whether tuberculin was or was not dangerous. Colonel Juler thought it was, but the last speaker (Professor Ballantyne) was of a different opinion, and he was right. It was only dangerous if improperly used. It was really quite easy to find the cause in these cases upon which the value of tuberculin and other antigens depended. The kidneys excreted the cause in its virus phase and it could be grown from the urine. He would like to put it in this way, that one of the difficulties in the assessment of the lesions with micro-organisms was that the micro-organisms were not seen in the lesions themselves, because the organisms were in the virus phase. With regard to the changes produced by tuberculosis, one found that only one phase of the tubercle bacillus was considered, namely, the acid-fast phase. It was only in that phase that the tubercle bacillus produced caseation, and then they could be seen in the lesions. Caseation did not occur in the sarcoid condition. In the other phases, those of non-acid-fastness and the phase *in virus* sarcoid changes were forthcoming.

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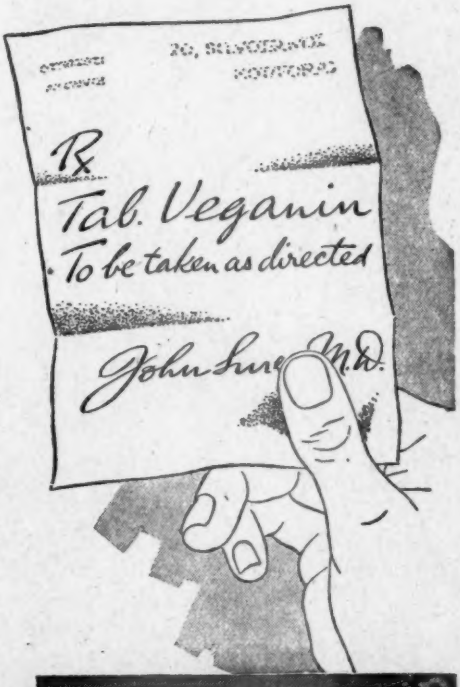

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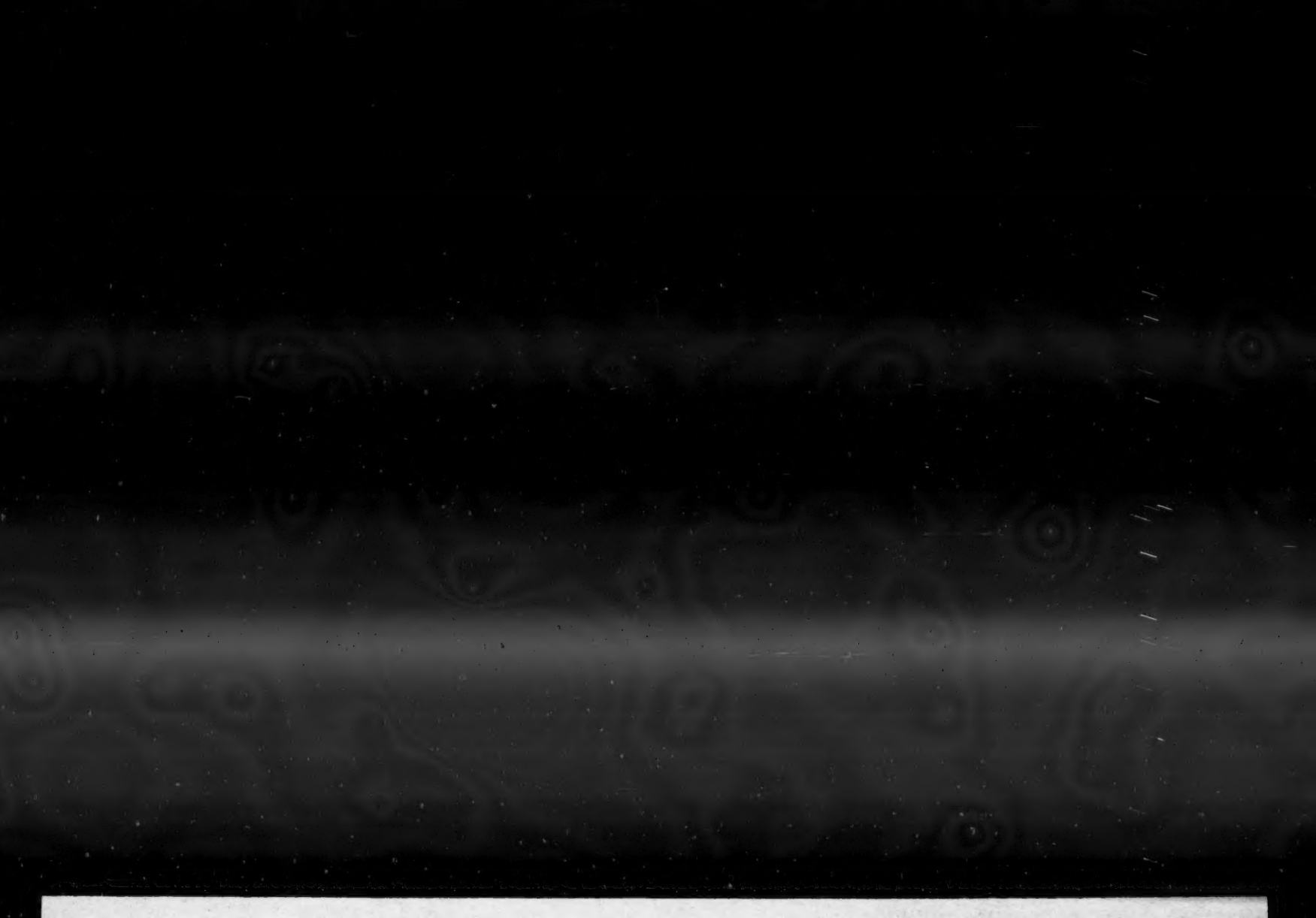
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